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CONTENTS

		Page
N. W. Simmonds	*A Banana Collecting Expedition to South East Asia and the Pacific*	251
J. E. Mayne	*Progress in the Mechanization of Farming in the Colonial Territories. III*	272
A. L. Jolly	*A Progress Report on Clip-card Accounting*	278
T. O. Elias	*Some Current Problems of African Land Tenure*	287
H. von Strenge	*Wild Coffee in Kaffa Province of Ethiopia*	297
W. J. A. Payne	Ipomoea reptans, *Poir. A Useful Tropical Fodder Plant* ..	302
R. A. Yates	*The Germination of Cane Cuttings*	306
H. Broeshart	*Application of Foliar Analysis to Oil Palm Cultivation. III* ..	315
Book Reviews	.. ..	321
Recent Publications	.. ..	324

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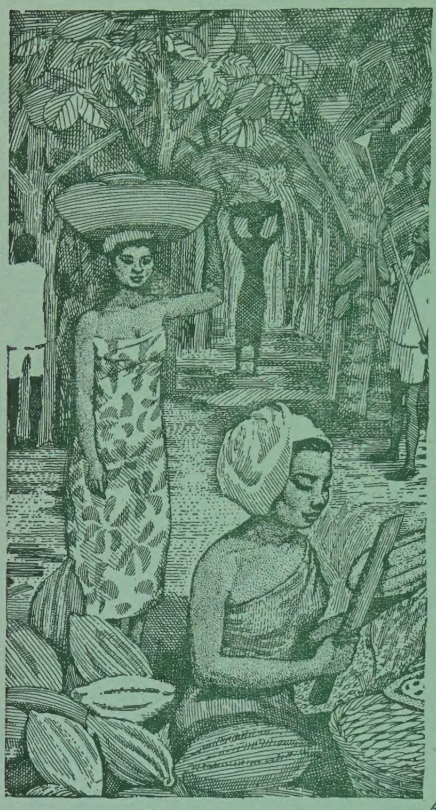
The case of *Acrocercrops cramerella*...



In Java, the cacao beans from which cocoa is made are heavily damaged by the small moth *A. cramerella* — the cacao pod borer. The pods are damaged directly by the boring larvae, and indirectly by fungi, which infect the boreholes, causing further destruction.

Cacao plants bear their pods throughout the year, thus the cycle of infection is continuous and has always been difficult to disrupt. Until recently, the only method was to strip the pods and flowers from the plants during a period of from three to six weeks annually, and so break the life cycle of the pests. Now this wasteful, expensive and, at best, temporary control is being replaced by spraying with endrin, a new Shell insecticide of great persistence.

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A Banana Collecting Expedition to South East Asia and the Pacific

N. W. Simmonds

Regional Research Centre, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

Since its inception in the early 1920's, banana breeding has depended primarily for its breeding stocks on materials sent by correspondents from various parts of the tropics. Some material (mostly of edible varieties) also accrued as the result of the journeys of S. C. Harland[1] in 1925 and F. M. Howes[2] in 1928, undertaken under the aegis of the Colonial Research Committee and the Empire Marketing Board respectively. The collections of wild and cultivated bananas at the Imperial College of Tropical Agriculture have been built up in this way as the foundation of banana breeding operations in Trinidad and Jamaica. Until about 1938 all breeding crosses were made between Gros Michel and wild strains of *Musa acuminata* or among the derivatives of such crosses. Then an edible diploid was used as a male parent. In 1943, an important reappraisal, by K. S. Dodds[3], of the whole rationale of banana breeding showed that both wild and edible diploid strains of *M. acuminata* would probably be needed to achieve success.

Meanwhile, it had become obvious that available breeding stocks were few and that few new ones were contributed by correspondents in the eastern tropics. On botanical grounds it then seemed probable that the Malaya-Thailand-Burma area was the region most likely to yield useful material. Arrangements were therefore made for an expedition by E. E. Cheesman of the Imperial College of Tropical Agriculture Botany Department and E. J. H. Corner, then of the Singapore Botanical Gardens. This was in 1939 and the expedition had to be cancelled.

The new Banana Research Scheme was founded in 1947 and a vote of £10,000 was included to cover the cost of a major collecting expedition. Political conditions in the Far East were then such that the expedition could not be allowed and, instead, R. E. D. Baker and N. W. Simmonds undertook, in late 1948, a journey in East Africa to see whether the banana eating peoples there had varieties useful to the breeder. Much valuable information was accumulated and two out of the many varieties collected are now in use in banana breeding[1]. That expedition was, therefore, a limited success but it was in no way a substitute for the proposed expedition to Asia where a greater diversity of edible diploids was to be expected.

In 1953–54 the matter was raised again and Colonial Office and Foreign Office agreement was sought and obtained for two botanists to travel in various selected countries of south east Asia. Until a late stage it was hoped that Baker and Simmonds would make the journey but, in the event, Baker could not be released and Simmonds went alone. Funds were made available under a special colonial development and welfare scheme administered by the Colonial Office. The journey began on 22 September, 1954 with the results set forth below.

The aims of the expedition were as follows: (*1*) to discover and collect wild and edible strains of *Musa acuminata* which, on the basis of bunch shape, fruit size and disease resistance, might be of value in banana breeding; (*2*) to amass all the scientific information about the bananas, both wild and cultivated, that could be obtained in the time available with a view both to improving fundamental knowledge of the group and to meeting future practical problems.

The route followed was determined by these aims, qualified by the political exigencies of the moment. Samoa, Queensland and New Guinea were chosen as areas in which *Musa banksii* was to be found; this species is co-specific with *M. acuminata* and some introductions of this species to the Imperial College of Tropical Agriculture, though growing weakly under Trinidad conditions, had borne exceptionally large fruits. Queensland had the added interest of being the home of two imperfectly known wild species and New Guinea, it was predicted, would probably provide much valuable data on the botany of the group. Indonesia, the Philippines and Borneo were thought to be unlikely places to find breeding stocks and the former was too chaotic to be a suitable place for the itinerant botanist to visit. Malaya, at least the north of the country, was thought to be a promising area and was included on learning that work in the jungles was possible under armed protection. Southern Burma almost certainly has breeding material to offer but the whole country had to be excluded on political grounds. Thailand, however, could be visited and, though there was no direct evidence of the existence there of breeding strains of *M. acuminata*, it was thought possible that Burmese forms might occur and it was known that there was much interesting botany to be done. Assam and Sikkim were included on purely botanical grounds, though there was a small chance that a useful form of *M. acuminata* was to be found in Assam.

The route followed, Samoa, Queensland, New Guinea, Malaya, Thailand, India, was chosen for reasons of climate; leaving England in the summer of 1954, and estimating a period of eight months in the field, it was thought best to leave the monsoon countries (Thailand and India) until the last, at a time when the rains should have ceased, the bananas should be in good condition and travel should be easiest. In the event, departure was delayed until September and the monsoon countries were reached late in the dry season when the plants were suffering from fierce drought and heat and when travel was temporarily complicated by pre-monsoon thunder and hailstorms. The plan, however, was good and there is little doubt that the period December to February is not only the best but also the most comfortable for banana botany in the areas subject to monsoon rains.

SAMOA AND FIJI

I left London by air on the evening of 22 September, 1954 and travelled westwards across the U.S.A. and the Pacific to Fiji. After one night in Suva I caught the fortnightly flying boat to Samoa and spent the following three weeks there, working in the islands of Upolu (on which lies the capital, Apia) and Savaii. The islands are of the oceanic–volcanic type; the slopes are gentle, the shores are fringed with reefs and the soils are fertile. The Samoans are a Polynesian people of great personal charm and there must

be few places in the world where the visitor is so hospitably received as in the villages of these islands. In Upolu I made day trips from Apia, usually in company with W. B. LAING or J. SCHWENKE; in Savaii I moved from village to village under the guidance of LOFIPO, who was not only excellent and informative company but was also, being a chief, well-qualified in the observance of the forms of polite address appropriate to travellers.

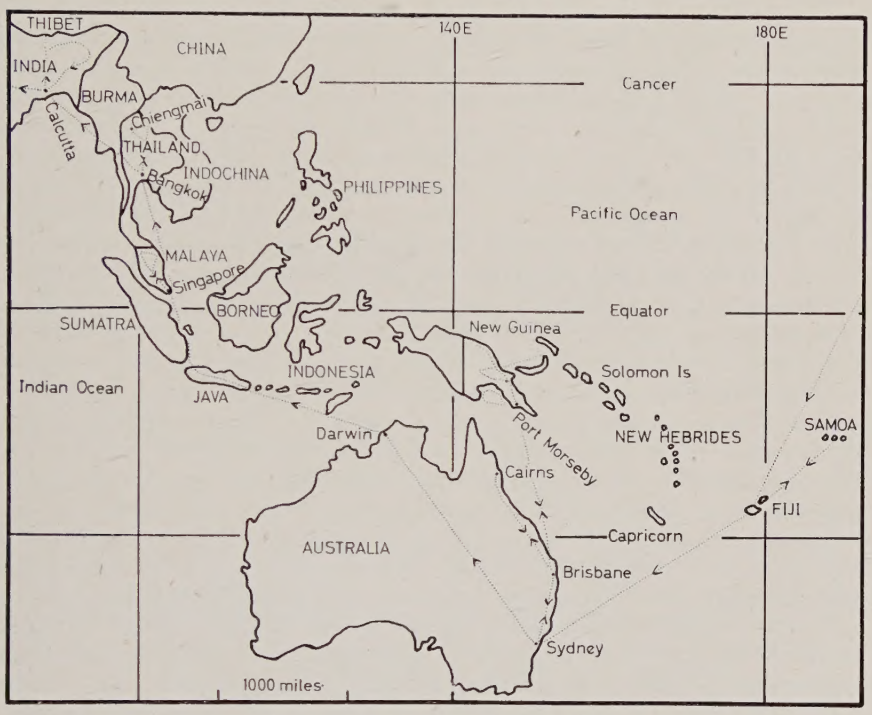

Figure 1. General course of the expedition

Musa banksii is a common wild plant, especially on the lower hill slopes and collections were made in both islands. The plants bore big bunches of large fruits but the bunches, though nearly vertical, were not of good habit, for the fingers splayed out in an irregular manner. The cultivated bananas of the islands were mostly familiar pantropical varieties; one, however, was clearly allied to the slightly mysterious edible Eumusas of Hawaii and three others were forms of the even more mysterious *Musa fehi*.

Samoa has a small export trade in bananas; fruit is shipped to New Zealand together with fruit from Tonga and Fiji and I was able to learn something from H. NEWTON of the problems encountered and the methods used to overcome them.

On return to Fiji the Samoan collection was packed and despatched. B. V. PARHAM, N. LAMONT, A. R. BROWNING and R. BURNESS of the Department of Agriculture; and A. B. ACKLAND of the Fijian Banana Venture all gave me much help in this connection. I saw here Bunchy Top disease for the first time—doing surprisingly little damage though virtually uncontrolled in peasant cultivations.

QUEENSLAND

The last few days of October were spent going to Brisbane *via* Sydney and in a visit to the banana cultivations around Nambour near Brisbane, with F. W. BERRILL, Banana Agronomist to the Queensland Department of Agriculture. Useful observations were made on problems of varietal identity in the Cavendish group of bananas. A short visit to cultivations south of Brisbane with K. M. WARD (Senior Horticulturist, Vegetable Crops) followed and then I flew up to the north east of Queensland to start work on the wild bananas in company with S. E. STEPHENS, Tropical Horticulturist, whose unrivalled knowledge of the country and local contacts were of inestimable value. We were joined later by F. W. BERRILL and S. T. BLAKE* and began working in the area between Tully and Mossman. This coastal strip of Queensland is the wettest part of Australia. It owes its rainfall to the combination of rain-bearing easterly winds off the Pacific with the topographical effect of the dividing range running athwart the winds. Where the range dips down (as it does north of Mossman) the rainfall drops; behind the range, in the rain-shadow, is the dry stock of Western Queensland. In this relatively tiny moist corner of the continent are tropical rain forests with a flora similar to that of Malaysia and it is in the second growth of these forests that the wild bananas are found. *Musa banksii* was present though not in great amount; several collections were made though the bunches, being mostly oblique and having comparatively small fruits, were not especially attractive. Search for *Musa hillii* and *M. fitzalani* on the Daintree river (the type locality for both species) was unsuccessful and we were driven to the tentative conclusion that they are extinct, a conclusion that gains much weight from the fact that Stephens had been looking for them for many years. The former is (or was) an Australimusa closely allied to a New Guinea plant, *Musa maclayi*, which is of especial interest as the probable source of the interesting group of Pacific edible types referred to as *Musa troglodytarum*, *M. fehi*, *etc*, but lamentably little understood botanically. *Musa fitzalani* cannot even be definitely assigned to a section but the most likely relationship for it seems to be to another New Guinea banana, probably a Eumusa.

The most troublesome disease of cultivated bananas in Australia is the virus Bunchy Top. In all the main growing areas it is kept under control by inspection and roguing. North Queensland produces bananas only for local consumption and rigorous quarantine measures kept it free of the disease for many years. Shortly before I arrived in the area, however, Bunchy Top had been detected in and around Cairns. Department of Agriculture teams, skilled in the treatment of the disease further south, were embarking on a programme of eradication. An unhappy event was the discovery of infected wild plants of *Musa banksii* at Waugh's pocket; the existence of a reservoir of disease in the bush outside the banana cultivations must considerably increase the difficulties of control—as has, of course, been found with many other virus diseases. Magee showed many years ago that *M. banksii* was susceptible to experimental infection but this was apparently the first record of natural infection; indeed it was probably the first time that the opportunity for such infection had occurred. It was this event that, in part, prompted investigation into the host range of the virus referred to below.

* Botanist, Brisbane Botanical Garden

NEW GUINEA

The journey in New Guinea was the longest and perhaps the most important part of the expedition and was divided into three phases: first in the islands of New Britain and New Ireland working mainly on the edible bananas, secondly in New Guinea proper and thirdly in the trawler *Tami* in the Gulf of Papua.

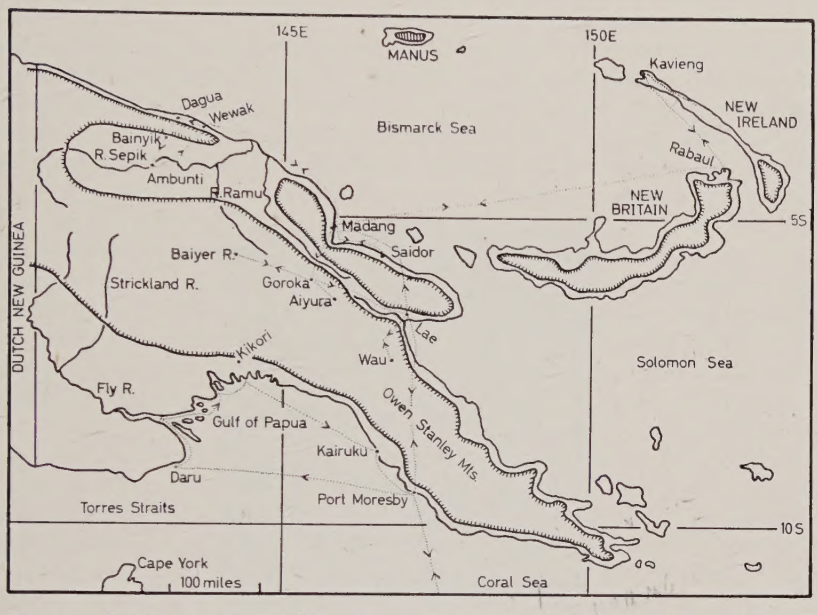

Figure 2. Sketch map of Eastern New Guinea: Margins of hill areas hachured, route shown as a dotted line, coastlines and international boundaries shown as solid lines

On arrival in the Territory on 21 November, I spent a day in Lae and held useful discussions with the Forest Botanist, J. S. WOMERSLEY. It had been arranged that he should accompany me on all or most of my trip in New Guinea and Papua proper. The next day I flew to Rabaul in New Britain where I was met and taken out to Keravat Agricultural Station by A. CHARLES, Economic Botanist, and acting head of the station. Two days later J. RICHARDSON and I flew to Kavieng, New Ireland. *Ensete calospermum* and *Musa maclayi* were found but no *M. banksii* or any trace of a species that might be it. Neither did we find *M. peekelii*, recorded from Namatanai at the other end of the island. The *Ensete* was originally described as *Musa* but it and its relatives are clearly generically distinct from the true bananas; *Ensete calospermum* is the most easterly member of the genus (which ranges all the way to West Africa); *Musa maclayi* and *M. peekelii* are both Australimusae and both are of much interest, the former for its relationship to *Musa fehi*, the latter as a potential sourse of genes for the improvement of Manila hemp (see pp. 256 and 270).

On return to Keravat, excursions were made in the Gazelle Peninsula and *Ensete* found again together with *Musa balbisiana* (the most easterly record of the species) but not *M. banksii*; evidently we were outside the

eastern limit of the latter. Time spent observing the edible bananas was rewarded by the discovery that the cultigens of the Peninsula (as of New Ireland and, as later work showed, of New Guinea proper and Papua, too) were mostly diploid; in this the assemblage is unique, for every other banana cultivation known to me is founded on triploids with occasional diploids only. In this New Guinea area therefore there is a botanically primitive group of cultigens which is now being invaded by the more vigorous triploids of recent European introduction. The process of invasion may be seen almost diagrammatically by comparing the types grown in the gardens and those grown along roadsides and in backyards, the former diploids and the latter invading triploids. Before European influence started to affect the situation, the cultivation must have been almost entirely of diploids in a state of evolutionary advance that existed in, say, Malaya, several millennia ago. The anthropological corollary is that New Guinea received its cultigens from the west at a comparatively early stage in the domesticated evolution of the group and preserved them in a virtually unchanged condition; in short, primitive bananas match the primitive technologies of the indigenes.

These edible diploids were interesting and curious rather than potentially useful. Thus, though there was one kind that had almost perfectly continuous spiral bract insertions, there was little of promise for banana breeding. Arrangements, however, are in hand to import some varieties to Trinidad for further study.

While at Keravat I took the opportunity to see some of the work of the station. Cacao and Manila hemp are being developed as crops suitable to the fertile volcanic ash and high rainfall of the area. The hemp had, some time previously, been eradicated from the Territory following the discovery of C. J. MAGEE[5] that a possible mild strain of Bunchy Top was present on old plantings. New stocks were being built up from seed and I promised help, not so much in supplying bulk stocks of *Musa textilis* (for they are not available in collections at the Imperial College of Tropical Agriculture), as in sending certain interspecific hybrids with other Australimusae which we knew throve and which might prove to be of breeding value. For example, the hybrid with *M. peekelii* (the species we failed to find in New Ireland) we have regarded as a possible source of drought-hardy stocks. The potentialities of interspecific hybridization for hemp improvement are, we believe, considerable, and it is good to be able to record that, at the time of writing (February, 1956), J. RICHARDSON, working at the Imperial College of Tropical Agriculture, has made an excellent start in investigating the field.

I flew back to Lae on 4 December and spent the next day with J. S. Womersley making final arrangements for our subsequent travels. On 6th we flew westwards on the first leg of what proved to be the most interesting and profitable journey I have ever made. Everything conspired to make it so—the natural splendour of the scenery, the richness of the flora, the primitive nature of the inhabitants, the helpfulness of Territory officials, the varied modes of travel and the skill and knowledge of my mentor.

The eastern (Australian) end of the island of New Guinea is composed essentially of a mass of parallel east-west mountain ranges separated by highland valleys and flanked by plains of varying extent. The plains are most highly developed in the Sepik-Ramu area of the north-central coast,

and in the corresponding area in Papua, the great flats of the Fly and Trans-Fly country. Further east, the mountains generally approach closely to the sea and coastal plains are but slightly developed. The mountains have a maximum of 16,000 ft and, the ground being extremely broken and the rivers unnavigable, large areas are still unexplored, though often well covered by aerial photography. The Central Highlands were only seriously penetrated in the 1930's. The large populations of these valleys are still extremely primitive and have been and still are a rich field for anthropological investigation. Cultivation (mainly of the sweet potato) is intense and little forest remains in the highland areas that carry large populations; the coastal regions are, in general, less densely populated and therefore much better wooded (though this is not to say that simple population pressure is the sole factor in forest regeneration).

Figure 3. Musa banksii, *B.E. 7, at Liverpool Creek near Innisfail, Northern Queensland: the older leaves, top left, are severely attacked by* Cordana *leaf-spot*

Communications are made difficult by the broken topography: the highland rivers are unnavigable and roads are very expensive to build and maintain. Virtually all long distance travel is by small aircraft. On the ground, jeep, horse and foot are used for local travel. The horse is perhaps the pleasantest of them and has the undoubted merit of being a pleasanter means of crossing rivers than either of the other two.

After leaving Lae our first stop was at Dagua on the north coast. From there we flew across the Torricelli range to the northern edge of the Sepik plains at Maprik. The resemblance in physiography, soil and vegetation of these plains to comparable plains in the New World tropics (*e.g.* the savannas of Trinidad and, I suspect, British Guiana) is remarkable. Probably both represent senile land surfaces. Their vegetation is an edaphic grassland tolerant of bad drainage—bush, cultivations and bananas being confined to the stream banks and to the neighbouring foothills. An afternoon was spent at Ambunti, flying in from Maprik by the mail plane and out later in the day to Wewak, catching a distant glimpse *en route* of the fabulous Tchambuli lakes with their miles of waterlilies. Ambunti lies on a small

hill in a curve of the river Sepik. The slopes on which we botanized were exposed to the sun and to an intense glare from the river and were sheltered from the wind; after a few hours of field work there we both felt in a state bordering on heat exhaustion. Some fine *Musa banksii* with big fruits were the reward, however. The results of collecting in the northern Sepik area were as follows: several collections of *M. banksii*, those from Ambunti being the most promising, though they had the splayed fingers found also in the Samoan plants; a new species of *Eumusa* which was common in the Dagua-Maprik area and which we later found to be the most widely spread species in the Territory; edible bananas were not much cultivated but it was clear that diploids formed a significant proportion of them; *Musa fehi* was seen in the hills above Maprik and local reports there and elsewhere made it clear that it is widely though thinly cultivated ('encouraged' might be a better word) in hilly country all along the north coast of New Guinea.

From Wewak we went eastwards to Madang and thence made two excursions, one to the foot of the Gogol valley where enormous quantities of *Musa angustigemma* (an Australimusa allied to *M. peekelii*), were found and some excellent *M. banksii*, the latter with much better shaped bunches and fingers than had the Ambunti plants. The other excursion was to Saidor and for this purpose we were granted the loan of the Government trawler *Koro* under the command of Captain ALDRICH. We found *M. angustigemma*, the new species noted first at Dagua and much *Ensete calospermum*. The latter was thriving under severe grass competition, on the abandoned war-time airfield which had been built on the sandy delta of the river Nankina a situation in which no *Musa* could establish itself, let alone survive and re-establish itself from seed.

The last few days before Christmas were spent in the Highlands. Goroka was our first stop and it yielded some information about the edible varieties grown by the highland people; the bananas were neither numerous nor well grown and the local practice of cutting off the male buds to encourage the fruit and then tying up the bunch in a sort of trash parcel—the reason for this operation is uncertain—made serious banana botany virtually impossible. Probably, however, some diploids were present.

The Baiyer River, the most westerly point in the highlands reached, was our next stop. It produced superficially the most promising collections of the whole expedition, as well as more material of the new species noted first at Dagua. The Baiyer River valley is now but thinly populated but the absence of forests in the main valley and various other signs show that it must have been more densely populated in the past. The agricultural station there is largely given over to stock and it was with the officer-in-charge, D. MURRAY, that we rode into the nearest forest to find the bananas. The altitude was about 4000 ft and the vegetation was floristically lowland-type rain forest interspersed with emergents of the great *Araucariae* characteristic of New Guinea but better developed elsewhere in the island. The fact that the forest, apart from containing *Araucaria*, was of lowland type gives cause for hope that it will be possible to grow the bananas successfully at low elevations in the West Indies. The bunches of *Musa banksii* were magnificent in all respects and three groups of mature seed were obtained.

From the Baiyer river we flew to Aiyura, where we stayed with the officer-in-charge of the agricultural station, A. SCHINDLER, and thence made a jeep excursion over the Chasan Gap to the head of the Markham valley. The spectacular siting of the road, the *Araucariae*, distant glimpses of the Finisterre ranges and mechanical defects in the jeep all combined to make the excursion a memorable one. No *Musa banksii* was found in this area but *Ensete calospermum* and the new species from Dagua were again collected. More exciting than these however, was an *Ensete*, known previously to Womersley, which grew in a mixed *Nothofagus* forest at Aiyura at an altitude of about 5900 ft. This plant, of which we obtained good museum collections but no mature seed, establishes a new record for size in herbs; the pseudostems are nearly 40 ft in height and a whole plant must weigh three to four tons. Womersley has since found it in several localities at high altitudes in New Guinea and has made good seed collections from which it is hoped to be able to grow the species in the West Indies.

Figure 4. Musa banksii, *B.E. 5, from Falefa, Samoa: note large fingers and nearly vertical habit: the gappiness in this bunch is a consequence of attack by birds.*

Figure 5. Musa banksii, *B.E. 21, from Ambunti on the central Sepik river, New Guinea: The bunch has large fingers which are, however, almost ageotropic*

On 22 December we returned to Lae and made short excursions in the Markham valley. We found *Musa balbisiana* and *M. maclayi* as well as, yet again, the new species from Dagua. Our last excursion in New Guinea was in the hilly country around Wau. Only the new species from Dagua was found at Wau but collections of *Musa maclayi*, *M. banksii* and *M. balbisiana* were made between Bulolo and the coast. The bunches of *M. banksii* did not appear particularly promising for breeding purposes. *M. balbisiana* occupied, for a banana, a somewhat unusual habitat, in that it was present, and abundant, only in stony or sandy alluvial flats and in wet places on the lower hill slopes, always in the full sun.

On 6 January we set off westwards in the Government trawler *Tami* commanded by Captain H. RADCLIFFE. Two small circular storms (locally called *gubas*) delayed us in our arrival at Daru. From Daru we sailed some distance up the Oriomo river but found no wild bananas. The area is flat and swampy, the coastal regions occupied by mangrove vegetation;

inland, where the water is fresh, there is a thin strip of riverain forest, usually backed (so far as could be ascertained) by great stretches of Ti-tree (*Melaleuca*) savanna. Drainage is poor and the failure to find bananas here and in similar situations on other rivers is probably to be related to this fact. From Daru we worked up into the mouth of the Fly at Madiri and Gaima and then back towards Kairuku, calling at Omati and Kikori on the way. The standard chart of this area is, however, still that made by *H.M.S. Fly* in 1845; the navigational difficulties were therefore considerable. We found only *Musa banksii* and the same new species that was so common in New Guinea; the former had oblique bunches of little promise for banana breeding.

By the time we reached Kairuku, about half-way back to Port Moresby, the mechanical defects in the trawler were such that it seemed best that it should return to Moresby at once, leaving us to return by the fortnightly flying boat which was due a few days later. From Kairuku we were accompanied by the A.D.O., W. Tomasetti, on a short trip into the Mekeo. The Mekeo is an area of fertile alluvium laid down by the Angabunga river; the land is flat and Government is encouraging mechanized production of dry-land rice on a cooperative basis. We were joined by three officers concerned with this scheme: K. Tomlin, A. Graham and J. Macaulay. We travelled by a happy combination of launch, jeep, tractor, punt (expertly managed in the Cam style) and foot and spent a most interesting and instructive visit. We found only one wild banana, the new species from Dagua, and a number of interesting edible bananas some of which were certainly diploid; the wild species grew in a state of semi-cultivation, encouraged (though not planted) as a magical inducement to growth among its edible relatives. Bananas are an important food to the Mekeo people and are mostly grown on the *levées*, where drainage is perhaps better than elsewhere, but even then show a marked tendency to grow out of the ground.

A minor discovery of some interest was the use of seeds of *Ensete calospermum* for personal decoration; the nearest known station for this species is in northern New Guinea, across the central ranges. Investigations indicated that the seeds are a common article of trade and are probably passed (as other articles are known to pass) from hand to hand over comparatively great distances. As an indication of the difficulties that sometimes beset the botanist, we were told on first enquiry, by the owner of the necklace, that the seeds came from a large evergreen tree; in fact he did not know their origin and had we not been sure enough of their identity to make enquiries of other villagers, we would surely have accepted his answer as correct. Later enquiries in Port Moresby and elsewhere gave no precise indication of how and whence the seeds reach this part of Papua; the species is known to occur as far east as the Louisiade Archipelago and (as specimens in the British Museum show) its seeds are a common component of personal ornament throughout north eastern Papua and the neighbouring islands.

This was the end of our journey in the Gulf of Papua and on 20th we took the flying boat back to Port Moresby, spent two days botanizing in the Sogeri Plateau and Brown River districts. I also paid a short visit to Murwillumbah, New South Wales, in company with J. H. Smith, Assistant

Director of Agriculture, and R. C. Cannon, Senior Horticulturist, Plantation Crops; there we met R. G. Kebby of the New South Wales Department of Agriculture and spent an interesting day looking at cultivated banana problems with him. I met F. W. Berrill at Currumbin on my way back to Brisbane and then flew down to Sydney *en route* to Malaya. At Sydney

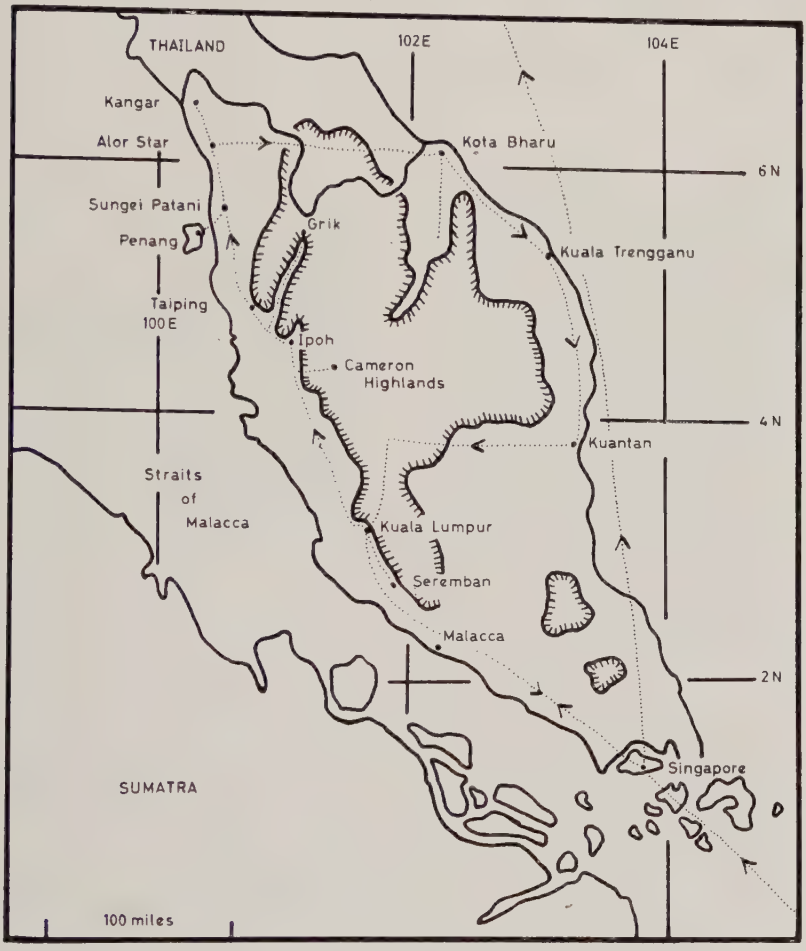

Figure 6. Sketch map of Malay Peninsula

I met and had useful discussions with C. J. Magee, Chief Pathologist to the New South Wales Department of Agriculture and foremost expert on Bunchy Top disease of bananas. We agreed to carry out a survey of specific susceptibility in the genus, I to supply the plants, Magee to do the tests.

MALAYA

I reached Singapore on 3 February and went on to Kuala Lumpur the next day. E. F. Allen was responsible for working out my itinerary in the country and, thanks to his help, it went very well. I also received

much help from R. B. Jagoe and M. Smith. Malaya is still in a politically disturbed condition and I learnt that most field excursions would have to be under the protection of armed escorts. The police and home guards who accompanied us had much local knowledge and proved to be outstandingly helpful and agreeable companions.

The peninsula is composed essentially of a chain of mountains flanked by plains; the plains produce the rice on which Malaya largely subsists; the foothills are mostly given over to rubber and the mountains to jungle. It was in the foothills that I was advised to look for bananas and this proved to be a wise choice. The general plan of movement was to work up the west side of the country from Kuala Lumpur to near the Thai border, to fly thence to Kelantan on the north east coast, to work down to Trengganu on the ground and fly back to Kuala Lumpur. This route, which excludes the south of the country, was made partly on the advice of Allen that the bananas would be more interesting in the north (this agreed with our impressions from introductions to the Imperial College of Tropical Agriculture), and partly on the grounds of expediency that the south of the country (in particular the state of Johore) was the most disturbed by bandit activity.

On 14 February I went up to Tanah Rata in the Cameron Highlands and spent several days in that area with R. Kanagaratnam. We found large quantities of *Musa truncata*, one of the many forms of the protean *M. acuminata*, and one which, as later investigation showed, is probably the same as *M. microcarpa* from Borneo; we also found hybrids between it and the lowland form of the species (*M. malaccensis*) at middle altitudes and made a collection of *M. violascens*, an elegant little Callimusa with an erect bunch and white and purple bracts. There was no material of promise for banana breeding, for the typical highland form of *M. acuminata* (*i.e. M. truncata*) usually has horizontal bunches of small fruit and cannot be grown at low altitudes. From the Cameron Highlands I went down to Ipoh and made that the base for several excursions in the neighbourhood in company with Ah Nooi, Assistant Agricultural Officer. We found one of the lowland forms of *M. acuminata* (*i.e. M. malaccensis*) and *M. violascens* and spent some time investigating the local edible varieties. From Ipoh I went up to Grik in northern Perak with L. A. Vivian, Agricultural Officer, Northern Perak. Grik lies in the extreme north of the State at low elevation although surrounded by hills; *Musa truncata* descends to low altitude in the district and some strains of it, perhaps of hybrid origin, have large oblique bunches bearing fair-sized fruits. We found several promising ones which were not however mature and Vivian undertook to have seed collected from them later and sent to the Imperial College of Tropical Agriculture. These bunches were the last wild types of any breeding promise found on the expedition and it will be interesting to see how they look when grown alongside the New Guinea collections in Trinidad. Vivian had detected an edible banana of possible interest in the area and we eventually saw two bunches of it; despite a rather unpromising name (*Pisang jari buaya*— ' crocodile's fingers ') it seemed to be an edible diploid of distinctly promising aspect and is being brought to the Imperial College of Tropical Agriculture for further study.

The rest of the trip on the west side of the country took me from Kuala Kangsar to Taiping, Sungei Patani, Alor Star and Kangar, in company with Che Ahmad, Salim bin Akib, Samad bin Osman, Mohammed Noor and Che Hamid. With Ahmad, I paid a most interesting though all too short visit to Penang where we saw the famous Ayer Itam temple. Throughout Kedah and Perlis is found a lowland form of *M. acuminata* slightly but definitely distinct from the Selangor form (*Musa malaccensis*) found further south; it occurs locally abundantly in the debris at the bases of the limestone cliffs, in which this area of Malaya abounds, and is of no possible value for banana breeding. On 6 March I flew to Kota Bharu in Kelantan and

Figure 7. Musa banksii, *B.E. 32, near Madang, New Guinea: Note large, nearly vertical bunch, large fruits and also slight ageotropism in the basal hands*

Figure 8. Musa banksii, *B.E. 34, from the Baiyer river, Western Highlands, New Guinea: outstanding for the great size and symmetry of its bunches*

worked for the next few days with M. F. Strickland. We found the same form of *M. acuminata* as occurred on the north west coast and in Trengganu collected material of *Musa gracilis*, a Callimusa allied to *M. violascens* which replaces that species in the east and south of the Peninsula. *Musa balbisiana* occurred as a cultivated plant grown for its leaves, which are better for wrapping than those of the edible kinds; it is not apparently native to Malaya. On 11 March I flew back to Kuala Lumpur and spent the following week despatching collections and making short local excursions with the Government Botanist, L. N. H. Larter. The collections of edible bananas maintained at Serdang by the Department of Agriculture proved most useful and, we were able, by using information from the Department's files and from my field notes, to make a fairly definitive list of Malayan edible types. Two or three diploid varieties appeared to be of some promise for banana breeding and E. F. Allen undertook to have them sent to Kew for quarantine. From Kuala Lumpur I went on to Singapore to examine the collections of bananas in the herbarium there. I received much help from the Director, J. W. Purseglove, and the herbarium staff. The main result of this visit was the recognition of a new species of *Rhodochlamys* from North Borneo and arrangements are in train to import it to the Imperial College of Tropical Agriculture for study.

THAILAND

From Singapore I flew to Bangkok on 23 March and, with the help of the British Embassy, made contact with the Ministry of Agriculture. AROON SONGMANI was deputed to assist me and was of great help. Bangkok lies near the seaward edge of the great central plain of Thailand, a plain which is almost entirely given over to rice and which is flanked on the east, the north, and the west by the hilly borders of the neighbouring states. Thailand has a monsoon climate and there was no possibility of finding wild bananas anywhere but in the hills. Accordingly, two excursions were planned, one to the northern capital of the country, Chiengmai, the other to the lower Burma border west of Bangkok. In the event, it proved feasible to make only the first of these two excursions and I travelled up to Chiengmai by train on 29 March.

The country around Chiengmai (except for the flats which are cultivated in rice) is mainly occupied by mixed deciduous forest in which teak is conspicuous; the contrast between the dry season aspect of the teak on the slopes and ridges and the mesophyllous vegetation of the gullies is remarkable. I was given much help in making arrangements to work in the district by the British Consul, E. H. JACOBS-LARKCOM, and by the Department of Agriculture by whom I was loaned the services of CHAREAN KENSWADI whose local knowledge proved of great assistance. Excursions to Doi Chiengdao and Doi Sutep mountains near Chiengmai about 7000 and 5500 ft high respectively, yielded no fewer than five wild banana species of which one was *M. acuminata* probably identical with the form found in northern Malaya and Indochina and quite useless for breeding. There were also: an interesting *Ensete*, probably *E. glaucum*, known from Burma; *Musa itinerans*, previously known from northern Burma; probable *M. nagensium*, from far north eastern Assam and northern Burma; and a curious little plant which proved to be an intersectional hybrid between *M. rubra* and *M. acuminata*—the former parent, a Rhodochlamys, was almost certainly present in the area but had suffered a dry season die-back. *Musa balbisiana* was not infrequently cultivated in the backyards here and throughout the country but did not appear to be wild.

I was joined on 3 April by Songmani who had been unable to leave Bangkok previously. We flew down to Phrae on 4 April and spent the next few days collecting near Nan and at Pangtonpheung, at both of which we found more material of *Musa acuminata* and *M. itinerans*. At Nan we received much help from the Agricultural Officer, PHAO CHAILERS, and from the Forest Officer, DIREK SKUNAVONGSE. Pangtonpheung lies on the railway and we chose it from the train on the way north as a place that was at once easy of access and conveniently close to Uttaradit, where we caught the southbound express for return to Bangkok.

INDIA

On arrival at Calcutta I was met by T. C. ROY and K. C. BHAN, the latter having been deputed by the Government of India to accompany me during my travels in the country. A few days were spent in Calcutta making arrangements for our itinerary with officers of the Department of Agriculture of West Bengal; and in visiting the Calcutta Botanic Gardens at Shibpur

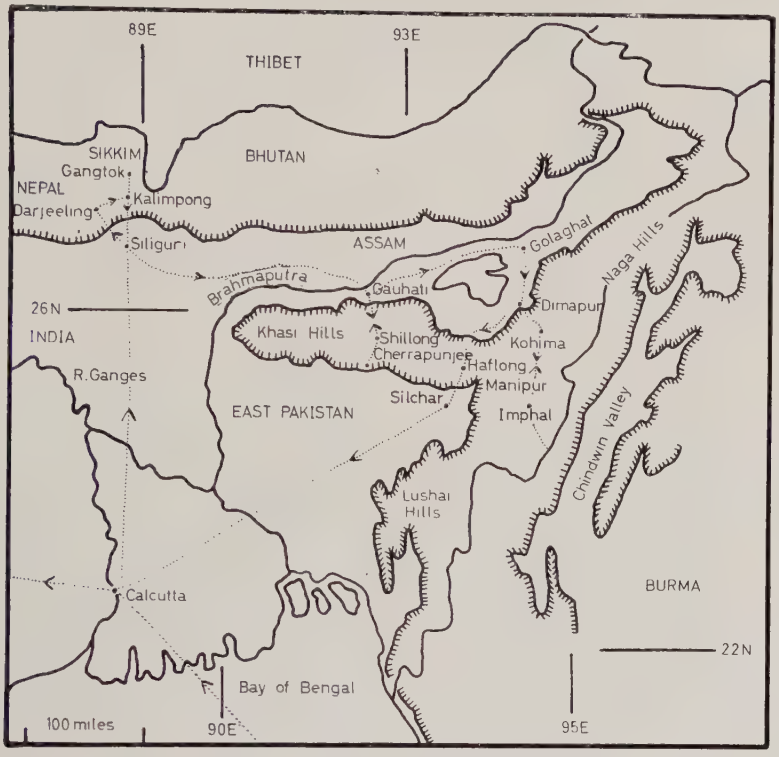

Figure 9. Sketch map of north eastern India

at which we were kindly received by the Director, Dr Biswas, and by S. K. Mukerjee. We set off by air for the Darjeeling district on 19 April and moved thence to Sikkim and Kalimpong. At Darjeeling good material was found of the high mountain Eumusa which was the principal reason for visiting the area; it is *Musa sikkimensis* and it is not uncommon in sheltered gullies up to about 7000 ft; it is not infrequently cultivated and the plants from which material was drawn probably came in this category. In Sikkim we stayed for a few days in Gangtok and I was kindly permitted by the Government of Sikkim to go beyond the Outer Line as far as Dikchu. *Musa sikkimensis* was found again, *M. balbisiana* at low altitudes and, at Dikchu, a collection was made of another species whose identity remains a mystery. We met and were assisted by many people in our travels in the Himalayas; I would like particularly to acknowledge the kindly hospitality of Raisahib B. B. Pradhan of Gangtok. From Kalimpong more material of *M. balbisiana* was collected on the Rangpo and up and down the lower stretches of the Tista gorge, but no other species. Botany was interrupted at one point on the Rangpo River by the discovery that we had been working for several hours in a grove of bananas where lurked a tiger which had done considerable execution among the local cattle and which, judging by its pug marks, was a large beast. At the Kalimpong Agricultural Station we were shown plants of an *Ensete*, probably *E. glaucum*, which had come from Burma some years before as a possible source of commercial fibre. On

28 April we boarded an eastbound train at Siliguri junction which lies on the plains near the foot of the Tista valley and travelled to Shillong by way of Gauhati.

We reached Shillong, which lies at about 6000 ft in the Khasi hills of Assam, in more stormy weather which continued for a short visit to Cherrapunjee on the southern edge of the hills. Cherrapunjee overlooks the plains of eastern Pakistan and its record as the wettest place in the world results from its exposure on the first major hill obstacle to the south west monsoon; the climate, the physiography and the vegetation all combine to make the district extraordinarily reminiscent of some parts of the west of Scotland; one felt that there ought to be trout in the burns. From Cherrapunjee we returned by way of Shillong to Gauhati, having seen four wild banana species in the hills: one was *M. balbisiana* which is generally distributed at low altitudes throughout this part of India; another was an undescribed species well known to us in our collections at the Imperial College of Tropical Agriculture as ' Mariani '; the third was a species of *Ensete* (probably *E. glaucum* again) cultivated at the Barnihat Agricultural Station, but native in the hills although rare; the fourth (of which we did not see flowers) was very probably *Musa sikkimensis* again. At Shillong we received much help from the Director of Agriculture, L. K. Handique, and from S. C. Bhattacharya. Kyrshan Singh was assigned to assist us and a jeep was placed at our disposal for the first few days of our subsequent travels.

From Gauhati we travelled north eastwards along the edge of the Mikir hills to Golaghat, finding *Musa balbisiana* and ' Mariani ' here and there. Near Golaghat we saw a very striking hybrid population between ' Mariani ' and *Musa velutina; M. velutina* is an elegant little Rhodochlamys with pink, dehiscent, hairy fruits and the discovery of this hybrid gave peculiar satisfaction for we had predicted on the basis of genetical experiments at the Imperial College of Tropical Agriculture that it should occur in nature.

The next stop was at Dimapur, the town at the Manipur road station and the starting point of the famous war-time road to Imphal. A day's work on the lower stretches of the road yielded *M. balbisiana*, ' Mariani ' and a new species of Eumusa. The new species, which was evidently allied to *Musa nagensium* and *M. sikkimensis*, throve on extremely exposed and stony hillsides and was clearly drought- and fire-resistant; no mature seed were obtained but good museum collections were made and we resolved to search for seed later. The road climbs steeply to Kohima and thither we went to Imphal. The Naga hills have, in general, a parallel-range structure (with some strikingly inconsequent drainage) and the road runs along the grain of the country from Kohima south westwards to Imphal. Some miles from Imphal the valley widens out in a most surprising fashion to the plain of Manipur, in the middle of which lies the town. The wild bananas are all to be sought in the surrounding hills and it was there we worked for the next few days with the help of members of the Forest Department. We found ' Mariani ' (probably—it was not flowering), *Musa itinerans*, *M. balbisiana* (in a state of cultivation) and a Eumusa similar to and doubtfully distinct from *M. sikkimensis*. The last was locally abundant near the Burma border and we found several mature bunches.

On 11 May we returned to Kohima and there met the Forest Ranger with whom we successfully sought mature seed of the new species that grew between Dimapur and Kohima. We left Manipur Road by train the next day and ended our field work in India with a short stay at Haflong, which lies most attractively in the hilly country of the Barail range, where the Jaintia hills abut on the Naga hills. More material of *M. balbisiana* and ' Mariani ' was the reward. From Haflong we took the train to Silchar and flew to Calcutta on 15 May. A short excursion was made to Krisnagar, an experiment station of the West Bengal Department of Agriculture, at which is maintained a collection of Indian banana varieties. The Director of the station, S. K. MUKHERJEE, received us very kindly and showed us something

Figure 10. New species discovered in New Guinea: the bunch of a Eumusa, *B.E. 13, collected at Dagua on the north central coast: the ' self-peeling ' fruits are conspicuous; the basal hands have rotted and shed their seeds but the dried relics of the skins persist*

Figure 11. The highland form of Musa acuminata *(or possibly a hybrid derivative) found near Grik in northern Perak, Malaya: this collection, having fairly long fingers, may be of use in banana breeding*

of his work on fruit trees. The banana collection was suffering from the effects of extreme drought and heat but it was clear that the vast majority of varieties, as we had found in the field in Assam, was of partial *M. balbisiana* parentage. This we had known previously, in a general way, from study of the literature but the visual demonstration of the fact was very striking; there was no indication of the occurrence of edible diploids of use in banana breeding and none, I think, is to be sought in India. Evidently, the drought characteristic of monsoon climates has guided the selection of drought-resistant types having some *balbisiana* in their make-up.

I left Calcutta by air on 22 May and reached London the day after. In England I did short spells of work at the Kew Herbarium and British Museum, had much of the essential photographic work for the expedition completed, and returned to Trinidad on the evening of 13 June.

RESULTS FOR BANANA BREEDING

The collections of promise for banana breeding are all diploid strains of *Musa acuminata* (including *M. banksii*); the majority were wild, seeded types but four or five promising edible kinds were found, as shown in *Table 1*.

Table 1

Type	*Origin*	*Number of collections*	*Collections growing in greenhouse or field at the Imperial College of Tropical Agriculture*
Wild	*Samoa*	5	3
	Queensland	4	2
	New Guinea	6	5
	Malaya	6	6
	Thailand	0	–
	India	0	–
	Total	21	16
Edible	*New Guinea*	1–2	*
	Malaya	3	*
	Total	4–5	–

*Not yet recieved—coming through quarantine at Kew and should be received at I.C.T.A. in 1956

The most promising collections are undoubtedly those from New Guinea, those from the Baiyer River (B.E. 34, 35, 36; Imperial College of Tropical Agriculture Intros 449–451) being the best; next comes a collection from Madang (B.E. 32; Imperial College of Tropical Agriculture 448); then the collections from Ambunti and Samoa (B.E. 21, 22; Imperial College of Tropical Agriculture 443–4, and B.E. 1–5; Imperial College of Tropical Agriculture 430–4); and, last, the Queensland collections (B.E. 6–9, Imperial College of Tropical Agriculture 436–8). The Malayan plants (B.E. 61A–D, 62, 63; Imperial College of Tropical Agriculture 491–6) can hardly be placed in the same scale; they may be taken to be roughly equivalent in promise to the Samoan plants. The edible diploids chosen had pendulous or oblique bunches and fair-sized fingers. Much investigation is needed before anything useful can be said about their potentialities.

The uses to which these stocks are put in banana breeding will depend on several factors—on disease resistance, on vigour in West Indian conditions, on their ability to combine satisfactorily in hybrids, on fertility (of the edible diploids) and so forth. At the time of writing the *M. banksii* in the field are very variable; the best of them are excellent but many have died and some are evidently susceptible to Leaf Spot. The Baiyer River plants are not thriving and it begins to look as though they are a high-altitude ecotype ill adapted to the lowlands; we propose to try them at height in Jamaica. Several years must elapse before experiments can have shown decisively which can be maintained, which are of value, and how to use them. We can only say now that the New Guinea *M. banksii* are superficially the most promising wild stocks that the banana breeder has ever had.

RESULTS

Taxonomy of wild bananas—In all, some 21 botanical entities were recognized. There were two interspecific (intersectional) hybrids among them and five species new to science. Another new species (from Borneo) was recognized in the collections of the Singapore Herbarium. Much useful information on known species was also gathered, perhaps the most valuable

being the definition of geographical variability in *Musa acuminata*. Seed collections of plants required for cytogenetic study at the Imperial College of Tropical Agriculture were made; museum collections and photographs were amassed for later deposition at Kew, duplicates being taken for the herbaria at Lae, Singapore and Calcutta. The collections made are summarized in *Table 2*; a list of the species found must await the formal taxonomic treatment presently in preparation.

Edible bananas—Much information on the edible bananas was acquired. The most important discovery was undoubtedly the existence of a cultivation of primitive diploids in New Guinea and a selection of about 20 of them is being imported to the Imperial College of Tropical Agriculture for intensive study. A strong correlation between botanical origins and climate was

Figure 12. One of the Malayan edible diploids of possible interest to banana breeders: Pisang jari buaya *at Kuala Kangsar: note nearly vertical bunch and comparatively large fingers*

Figure 13.—Musa balbisiana, *B.E. 83, by the Rangpo river on the border of Sikkim and India: abundant in north eastern India, this species has contributed much to the origins of the edible bananas*

Table 2. (a) Seeds to grow at the Imperial College of Tropical Agriculture (excluding breeding material) (b) Museum collections

Place	*Collections (a)*	*Species*	*Collections (b)*	*Species*
Samoa	0	–	2	1
Queensland	0	–	0	–
New Guinea	20	5	40	7
Malaya	7	3	8	5
Thailand	4	3	8	5*
India	7	4	11	7*

*Including one interspecific hybrid

also of interest: the bananas of the monsoon countries, Thailand and north eastern India, almost all owe their origins in part to *Musa balbisiana*, a species which is native in the monsoon area and resists the fierce dry season better than most wild bananas; apparently it confers this resistance on its edible descendants—selection for drought resistance has meant selection for *balbisiana* genes. We had long known that the bananas of India had much

M. balbisiana in them; a short experience of an Indian dry season shows why and shows also that we need not look to the monsoon lands for edible diploid stocks of *M. acuminata* for breeding purposes.

I also learned something of the problems of commercial cultivation of bananas in Samoa, Fiji, Queensland and New South Wales, and was able to resolve certain difficulties in the identification of members of the Cavendish group.

Miscellanea—I undertook to supply banana seeds for various purposes: Imperial College of Tropical Agriculture stocks of *Musa textilis* and *M. textilis* hybrids to Keravat, New Britain, for Manila hemp selection work (see p. 256); various wild stocks as ornamentals for cultivation at Lae botanical gardens; and as many members of the genus as possible to C. J. Magee at Sydney for test of reaction of Bunchy Top (see p. 261). This last project was prompted both by its intrinsic interest and by the potential value of the information if breeding against the disease should ever be undertaken.

SUMMARY

New stocks of both seeded and edible strains of diploid *Musa acuminata* are needed for banana breeding in the West Indies. The main results of a collecting expedition lasting eight months were: wild strains of *Musa acuminata* promising for banana breeding were found in Samoa, Queensland, New Guinea and Malaya and 21 seed collections were sent to the Imperial College of Tropical Agriculture; by far the most promising stocks came from northern and central New Guinea but they must be subjected to extensive testing and hybridization before their potentialities are fully known; some four or five promising edible diploids were seen and arrangements have been made to import them to the Imperial College of Tropical Agriculture by way of quarantine at Kew; much interesting botanical information was amassed and several new species and interspecific hybrids were recognized; 38 seed collections and 69 museum collections were made, the latter supplemented by notes and photographs; much was also learned about the edible bananas. A cultivation of primitive edible diploids was discovered in New Guinea—a situation of extraordinary evolutionary and ethnobotanical interest.

ACKNOWLEDGEMENTS

Many of the people who helped me in the field have been named; to all of them—and to others whose names I have inadvertently omitted—my most grateful thanks are due. The names of many more people whose generous advice, assistance and hospitality I accepted but who did not accompany me in the field I have deliberately excluded for reasons of space; their kindness, too, is gratefully acknowledged. Official bodies which contributed much to the expedition by assistance, advice and transport were many; to the Governments and Departments of Agriculture of Samoa, Fiji and Queensland; to the Government, Department of Agriculture and Department of Forestry of the Territory of Papua and New Guinea; to the Government and Department of Agriculture of the Federation of Malaya; to the Gardens Department, Singapore; to the Government and Ministry of Agriculture of Thailand; to the Government of India; to the Governments

and Departments of Agriculture of West Bengal and Assam; and to the Government of Sikkim my grateful thanks are also due. Many British Government agencies also gave invaluable help, notably: the Colonial Office (special acknowledgement is due to D. Rhind and J. Rose); United Kingdom High Commissions in Australia and India; the United Kingdom Trade Commission in Brisbane; the British Embassy and Consulate in Bangkok and the British Consulate in Chiengmai.

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REFERENCES

[1] Harland, S. C. (1928). Bananas and Citrus. *Trop. Agriculture, Trin.*, **5,** 23; 54; 90

[2] Howes, F. N. (1928). The banana in some tropical Eastern countries—its forms and variations. *Kew Bull. misc. Inf.*, 305

[3] Dodds, K. S. (1943). The genetic system of banana varieties in relation to banana breeding. *Emp. J. exp. Agric.*, **11,** 89

[4] Baker, R. E. D. and Simmonds, N. W. (1951–2). Bananas in East Africa, Pts 1 and 2, *ibid.*, **19,** 283; **20,** 66

[5] Magee, C. J. (1954). Report on a plant disease survey in the Territory of Papua and New Guinea Pt 1, Manila Hemp, *Papua & New Guinea agric. Gaz.*, **8,** 12

Progress in the Mechanization of Farming in the Colonial Territories—III

British Territories in the East

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Progress in introducing modern quantity produced equipment into tropical agriculture has been reviewed with particular reference to Central Africa, East Africa, and the High Commission Territories following a fact-finding tour in 1953[1] and with reference to West Africa following a tour in 1954[2]. The present paper deals with visits to Aden, Cyprus, and South East Asia.

THE TOURS

The author visited Cyprus and the Aden Protectorates during May and June, 1955, and North Borneo, Brunei, Sarawak, Singapore and the Federation of Malaya in October to December. The tours were made under the auspices of the Colonial Agricultural Machinery Advisory Committee with the helpful cooperation of the territorial governments. Information was collected from which three main conclusions were drawn.

(*a*) It has not been necessary for Government to sponsor mechanization *per se* in Cyprus, because fairly high wage rates have fostered the use of tractors and combine harvesters, especially in the wheat fields of the central plain, but there appears to be unnecessary diversification of equipment on the local market and, owing to the abrasive soils, the high cost of pneumatic tyre replacements is a serious factor in tractor economics. By contrast, in the Aden Protectorates Government has undertaken many of the services which would normally be rendered by manufacturers' agents in a more commercialized territory. It is hoped that commercial interests will now take over these activities which consist of a tractor agency and workshop, and a similar organization dealing with stationary engines and pumps.

The present need for mechanization is slight in North Borneo, but plans have been considered for the establishment of a tractor ploughing service to paddy farmers. In Brunei particular attention is being paid to experiments in cable haulage on uninhabited ' bottomless ' *padi* land, and the results will be of widespread interest, although the development of suitable implements is likely to take several years. The Department of Agriculture, Sarawak has gained considerable experience with small ' walking ' tractors and has demonstrated that, properly selected and operated, such machines need not be too exhausting to drive in the tropics. Medium tractors are in use for paddy cultivation on firm land.

Although Singapore is an important centre of the agricultural machinery trade, the companies so engaged have many other interests and do not all appear to have detailed first hand knowledge of the market in the region.

The rubber, oil palm and coconut estates in Malaya are becoming increasingly interested in mechanization, although the results of a recent census show that field work is completely unmechanized on the great majority. The small-holders have been reasonably well provided with opportunities to hire tractors and implements from Government, from the Development Authority or from small private contractors. The Department of Agriculture, Federation of Malaya, has been doing outstanding work in the investigation and furtherance of mechanization—especially amongst small-holders—and the trend of future work will probably be towards (*i*) the improvement of simple implements, and (*ii*) the investigation of paddy farming on a scale intended to occupy a tractor unit.

(*b*) Outstanding problems in Cyprus are the provision of suitable tractor power for the small vegetable farms, the mountain vineyards, and the breaking of 'kafkala' (limestone capped land) which frequently defies heavy crawler tractors with rippers, and which covers large areas of the island.

(*c*) In certain circumstances an initial impetus can be given to mechanization by Government (or an officially sponsored body) undertaking, on a non-profit basis, the functions normally performed by a commercial agency. Private enterprise may then be tempted to take over, and develop the going concern. One of the main advantages to the farmers of such an approach is that a considerable degree of standardization can be achieved in maintenance and repair techniques, and in the supply of spare parts. This approach has been used successfully in the Aden Protectorate where the Abyan board has maintained a tractor agency for several years, and Government has undertaken the supply and maintenance of pumps with diesel engines for irrigation from wells in the Wadi Hadhramaut.

COST OF MACHINERY OPERATIONS

In the Abyan area of the Western Aden Protectorate more than 100 tractors are owned and operated by Arab farmers whose main source of cash income is cotton marketed through the Abyan board. It was not possible to ascertain operating costs, but the tractors are maintained in the workshops of the Abyan board which acts as local agent for the manufacture of a popular tractor. The cost of workshop services rendered by the board is deducted from the monies due to the farmer on completion of the sale of the cotton crop by the board. The procedure, overall, is reported to have shown itself to be profitable to the farmers.

In South East Asia the impression was gained that, although first cost of tractors and machinery was high, the real cost of operating them was less than in West Africa and parts of East Africa. This was generally due to higher standards of maintenance and operation. In Malaya excellent communications (especially by road in country districts), and the higher standards of local industry and commerce, result in swifter service than in most of tropical Africa. The long establishment throughout the inhabited areas of Malaya of tin mining and rubber processing plant, together with the highly developed motor transport system and the recent military history of the country, appear to have resulted in a high level of mechanical competence amongst the skilled labour.

The following information was supplied by a Chinese contractor in Province Wellesley. He and his son own three tractors, one four-year old t.v.o. model Ferguson and two newer diesels. An operator is employed at a rate of $8.00* per eight-hour day, plus a paddy holding, but is not paid when the tractor is idle. The contractor charges $30.00 per acre for one treatment of wet paddy fields with a rotavator and finds that his services are in demand. This charge includes travelling to the site and allows for the inconvenience of working in bunded fields.

A rubber planter[3] described the cost of operating his caterpillar *D4* as $11.00 per hour and his *D8* as $21.00 per hour. These costs include charges of $4.00 and $8.00 respectively for depreciation and an additional $4.00 and $8.00 respectively to accumulate in a repairs fund. The *D8* could fell old rubber trees at a rate of 12 acres per day.

D. W. M. Haynes [4], following a standard system of costing adopted by the Department of Agriculture, Federation of Malaya, which provides for fuel, supplies, labour, repairs and depreciation, estimates the average total costs per acre of various paddy operations with Massey-Harris Ferguson tractors to be: ploughing $17.40, cultivating $15.78, combine harvesting $39.76. The actual costs calculated during a number of trials varied considerably and in one case the total cost per acre of mechanized paddy production exceeded $150, largely owing to difficult harvesting conditions.

MANUFACTURERS' AGENTS

The remarks on this subject in the previous papers[1,2] apply equally in principle to South East Asia, but the leading firms in Malaya have well-equipped branches in all the main towns and the excellent road system allows swift and easy access to outlying districts. The effects of the Emergency in Malaya are disregarded in the present paper. Good and frequent rail services between Singapore, Kuala Lumpur and other centres make the supply of parts and services more simple and rather more effective than in tropical Africa.

TECHNICAL PROGRESS

Paddy cultivation—Progress in mechanical paddy cultivation fostered by the Government of the Federation of Malaya has been reviewed in considerable detail elsewhere[5]. It is estimated that some 350 tractors are now available on hire to paddy farmers, of which two thirds are owned by small contractors who appear to be making reasonable profits. Important results of trials include:

(*a*) Areas cultivated ' in the wet ' have given significantly higher yields than those cultivated ' in the dry ' and subsequently flooded.

(*b*) Tractor ploughing in the wet has tended to give better yields than ploughing with the local buffalo-drawn wooden plough—apparently owing to better weed control.

(*c*) Deep ploughing (8 to 9 in.) and rotary cultivation do not give such high yields as shallow ploughing (4 to 5 in.), but sub-soiling does not reduce yields.

* $1.00 Malaya = 2s. 4d.

(*d*) Superficial cultivation (*e.g.* surface puddling) appears to give yields comparable with shallow ploughing.

(*e*) Following shallow ploughing, the less soil is worked in order to create a good condition for transplanting the better.

(*f*) Tractor ploughing four to six weeks before transplanting gives higher yields than either very early or later ploughing.

Experiments with cable equipment—The object of current trials in Brunei is to develop mechanical methods of cultivation, planting, and harvesting paddy to be used on extensive areas of very soft land. The land is undeveloped and undemarcated, although much of it is under forest, and it is assumed that it will be possible to lay out fairly large fields of regular shape which will be suitable for the operation of cable tackle. By using cable tackle it is hoped to eliminate traction problems on the soft land. The experimental equipment includes swampland versions of listed agricultural crawler tractors with side mounted winches, cable booms and counter-balance weights. It is envisaged that during work the tractors will remain on permanent headlands or causeways which will never be cultivated. The work is directed by consulting engineers on behalf of the Government of Brunei.

Paddy harvesting—It is too early to report in detail on the experiments in harvesting. Many machines have been, and are being, tried in various combinations, including mowers, reapers, headers, windrowers, self-binders and combine harvesters. Transportation is receiving attention, the following devices having been used: buckrake, jib transporter, transport boxes and a mechanical wheelbarrow. Local methods of threshing have been compared with several stripper threshers (in which the heads of sheaves are held against the threshing drum) and about ten conventional ' feed in ' threshers of various sizes. This work, which is still in progress, is exhaustive and the results will be of great value not only in Malaya, but also throughout South East Asia and in several African territories.

Brush and weed control in perennial crops—The control of bushy growth under tree crops is being increasingly mechanized in many tropical territories. While cutting to ground level is considered entirely acceptable under coconuts and oil palms, the ideal condition under rubber advocated by the Rubber Research Institute is a cover of broad leaved species about 3 ft high. Grasses (which are encouraged by close cutting) are not wanted under rubber. Nevertheless, the convenience of using machinery for bush control is recognized and many rubber planters are adopting rotary cutters. The roller cutter, however, is more suitable for controlling, yet preserving, low bush covers under tree crops, but is less convenient to transport and requires a more powerful tractor to do comparable work.

Land clearing—A considerable amount of land clearing is being undertaken in Malaya in connection with the rubber replanting scheme[3]. Methods in use include hand felling, poisoning, tractor felling, and tractor clearing by contractors. The view is frequently expressed that heavy tractors crossing and recrossing the land, which is frequently wet during clearing operations, cause compaction of certain soils which is detrimental to the growth of young rubber trees. No experimental evidence in confirmation of this belief can be found, but there would appear to be some truth in it.

Field drainage—Drainage is important on estates in many parts of Malaya[6]. Some covered pipe drains are used to collect water into supply tanks, but most drains are open. Many of the main drains are 11 or 12 ft wide. There is much variation in dimensions but field drains are commonly 3 ft deep and 3 ft wide at the top and 1 ft wide at the invert. Priestman *Cub* excavators are sometimes used with a locally fabricated tapered bucket scoop. Other equipment in use includes tractor-mounted hydraulic ditchers (such as *Hopto*, *Shawnee*, *Stanhay*, *Dinkum*) and small floating dredges (such as *Lilliput*). Larger scale work is undertaken by such equipment as the Priestman *Wolf* and the Ruston-Bucyrus *10*. Some estates could employ specialized drainage machinery for 340 days per year, but others would prefer equipment for attachment to popular tractors. Two distinct tasks are in need of further mechanization, drain digging which now costs $2.41 per chain, and drain clearing which costs $0.71. On certain non-scouring soils there is a very real need for a mechanical ejector in the buckets of excavators.

Pumping for irrigation from wells—A most interesting and stimulating development has been fostered in the arid Wadi Hadhramaut, Eastern Aden Protectorate. Pumps with diesel engines—supplied and maintained under government sponsorship—are replacing camels, donkeys and human beings as the means of raising water from wells which may be 15 to 80 ft deep. More than 400 wells are now mechanized, the engines being installed with the pumps almost at water level. Access is provided through an underground passage and staircase, the two openings, staircase and well, evidently providing for sufficient circulation of air to prevent the accumulation of toxic fumes in the well. The scheme has a serious economic drawback arising from the lack of exports from the Wadi. Equipment and fuel are delivered into the Wadi by camel trains, or lorries which must return empty, and this is very expensive. Imports into the Wadi are largely paid for with money remitted by emigrants from the Wadi to other parts of the world—notably the East Indies.

CONCLUSIONS

Having regard to experience gained during earlier tours[1,2] and to recent work[4,5,7–9], it is generally concluded that further study of farm mechanization in the Colonial Territories should be directed as follows: (*a*) Tracing the causes of high tractor operating costs: systematically (where appropriate, in confidence with the manufacturers) and attempting to reduce or eliminate them. (*b*) Continuing the general study of ' tractorization ', and intensifying the study of simple implements for wet paddy cultivation. (*c*) Examining methods of tillage appropriate to ' dry ' tropical soils, and considering the further development of special machinery for tropical crop production (*e.g.* maize and cotton planters).

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REFERENCES

[1] Mayne, J. E. (1954). Progress in the Mechanization of Farming in the Colonial Territories, I, *Trop. Agriculture, Trin.*, **31,** 3

[2] — (1955). Progress in the Mechanization of Farming in the Colonial Territories, II, *ibid*, **32,** 2

[3] MURRAY, W. (1954). *Planters' Bulletin*, Rubber Research Institute of Malaya, July
[4] HAYNES, D. W. M. (1954). Calculation of Costs of Mechanical Operation with Particular Reference to Mechanized Harvesting of Rice, *Malay. agric. J.* **37,** 54
[5] — (1955). *The Mechanical Cultivation of Wet Padi Land in the Federation of Malaya*, F.A.O. Regional Training Centre, Ampari, Ceylon
[6] *Machinery for Field Drainage: Deliberations of the Panel on Field Engineering* Colonial Agricultural Machinery Advisory Committee (unpublished)
[7] BALDWIN, K. D. S., *The Economics of Agricultural Mechanization in Nigeria.* Private communication
[8] *Mechanization of Agriculture*, Commission for Technical Cooperation in Africa South of the Sahara (1955), Report of Inter-African Conference, Entebbe
[9] NEWLYN, W. T., *A Study of Costs of Mechanized Agriculture in Nigeria*, Report issued by West African Institute of Social and Economic Research, Ibadan

A Progress Report on Clip-Card Accounting

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Clip-card accounting[1] which consists of keeping accounts on manually sortable cards of the Cope-Chat or McBee type was invented some ten years ago. In its simplest form the system achieves double entry by the two-way sortability of the cards; the card illustrated in *Figure 1*, showing the purchase of feeding stuffs on credit, can be sorted as a receipt into the feed store on the debit coding or as a debt contracted with the supplier on the credit coding. The mechanics and refinements of the system are explained in *Clip-Card Accounting on the Farm*[2]. The advantages claimed of the system are briefly that it imposes double entry on all phases of farm operation; it is a single system that can accommodate any event that may occur on the farm; it allows descriptive information to be entered on the actual accounting transaction; it eliminates transcription; and, like double entry, is infinitely flexible and can be used equally well for simple or complicated accounts.

There has not been a rapid increase in the use of this system over the past ten years for two reasons. First, publicity has been curtailed while the system was under experiment and development; it is only in the last five years that the ' slip-post ' feature, which allows the cards to be temporarily attached to a backing sheet, has been fully exploited. Secondly, the gulf between the accountant and the farmer which the system is intended to bridge has proved wider than expected. The professional accountant naturally thinks in terms of large volume accounts kept by full time bookkeepers working under his supervision; his problems and opportunities are very different from those of the amateur accountant keeping his own accounts under the often rather disordered conditions of a farm. The agriculturist on the other hand often does not appreciate the commercial value of the accounting discipline; he is too easily satisfied with the barest skeleton of financial accounting overlaid by a collection of miscellaneous record books; because these books are not integrated in any general accounting scheme, they have limited value and tend to prove that figures, although interesting, are of little practical help in improving profitability. This gulf can probably be narrowed only through agricultural education and it is rather depressing to observe that many agricultural colleges today pay less instead of more attention to the teaching of accountancy.

There is only one commercial farmer in the world, to the author's knowledge, who has installed and operated clip-card accounting entirely on his own initiative. A number of enquiries has been received from other commercial farmers but as far as is known none has yet adopted the system, although admittedly no one has started and subsequently discarded it. The unique individual who has adopted the system farms in Tanganyika

but the author unfortunately has not yet had the opportunity of seeing his farm and his accounts. But from correspondence he is obviously well satisfied with the cards and has made sound business progress during the five years they have been kept. During this time he has moved to a larger tract (now 1,000 acres) which he is in the process of developing and has formed a private company to operate his business with the aid of some capital obtained from outside sources. From his cards he produces audited accounts which conform with the local requirements of private companies. The system has evidently gained the confidence of both himself and his partners; it has given him the stimulus and courage to expand, and his partners the confidence to invest their savings. The farmer is undoubtedly well fitted in respect of the size of his business, his situation, ambitions and education to benefit from the system, but his comments are nevertheless flattering; for instance: 'I would not be without the cards for anything. They are the only device that gives figures one wants in the time one can spare'.

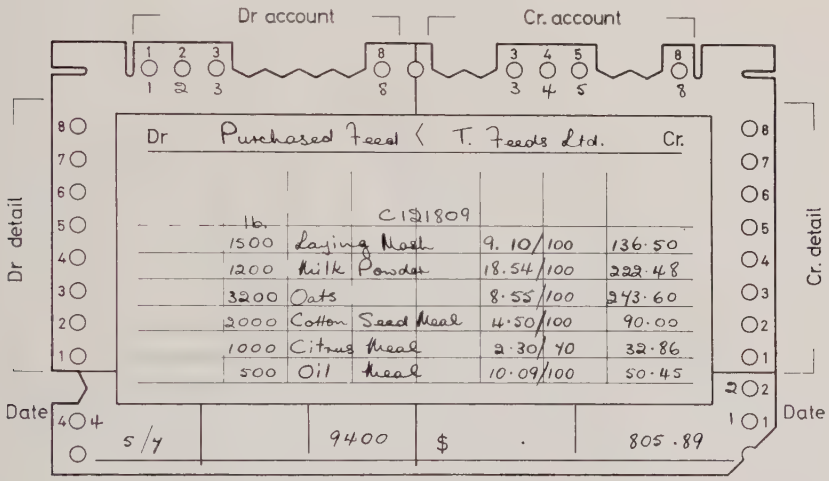

Figure 1

PEASANT INVESTIGATION

The main ground for testing and developing the system has been accounting projects in Trinidad sponsored and to a varying extent supervised by the author. The four most interesting are: the peasant investigation, a cocoa estate, a large dairy farm and a district agricultural station. The peasant investigation[3] was a research project designed to evolve profitable systems of small farming and has been accounted on cards for the past ten years. Each farm needs about a quarter of a hour clerical work per day in order to record and process the most elaborate information. To some it has appeared rather inappropriate to prepare a balance sheet and a profit and loss account for a peasant farm, but the strict accounting control that the cards have imposed and the wealth of information that they have provided have been largely responsible for clarifying the problems of the investigation and improving the financial results to what has been described

as an astonishing level. For instance, in the early years on a manual arable farm the net profit, after charging all outside costs including rent and depreciation, available to the peasant couple was less than $500 a year; by improving the organization and management on the information provided by the card accounts net profit has been increased to $1200 and is likely eventually to reach $1800 a year. The accounting problems for these tiny farms are in respect of detail rather than volume; only about 1000 cards a year are needed for each to accommodate the cost accounting of some 15 different enterprises with crops sub-costed on an operational classification. It has been calculated that if this amount of detail was kept in fixed leaf books they would contain about 100 30-line analysis pages with 10 to 20 columns each; to summarize any information other than that for which the pages were designed would involve laboriously re-abstracting the material. With the cards, as with any other slip system, it is a simple sorting and totalling process to extract details in any combination desired.

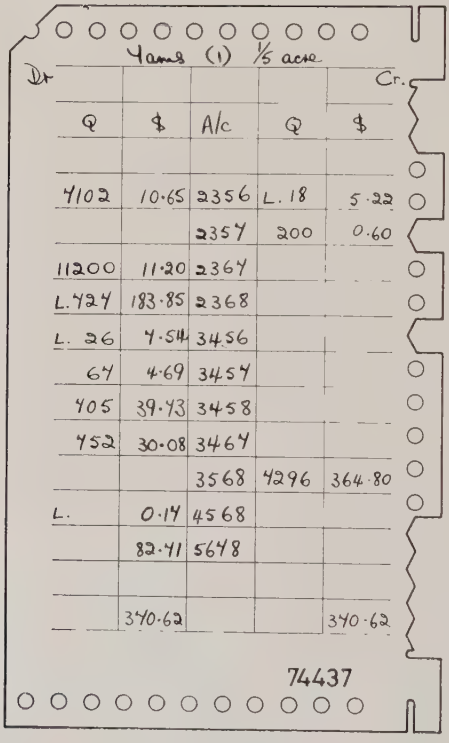

Figure 2

Accounting of this investigation was controlled by the author and could therefore provide material for developing the card technique. There have emerged the two standard types of card, *Universal* (*Figures 1* and *2*) and *Tab* (*Figures 3* and *6*); the latter has identical border printing, but is not ruled and carries a tear-off tab so that it can be bound to serve as a field

notebook. These accounts have developed the best coding system, filing arrangement and account closing procedure; they have proved the convenience of slip-post, of alternate-day ink colours, and of price adjustment. They have also demonstrated the possibility of making summaries as notes on the transaction cards; for instance, *Figure 2* summarizes the cost account of a yam crop on the back of a universal card. The first total on the debit side is for 7102 lb. of cane trash (dry leaves) transferred from other fields (code 2356); on the credit side a correction of a mischarge to this yam crop of 18 hours work; the last transaction, the profit of $82.71 (code 5678), is the actual transaction recorded on the face of the card; for convenience, the yield (36480 lb. per acre) and the labour income (36¢ per hour) are entered as notes also on the face of the card. Thus it has been found unnecessary to make any summaries on separate sheets or in books except for the use of outside readers; everything, from the origin and extent of wastage to the balance sheet of the farm, can be summarized on appropriate cards so that every scrap of information is included in the one file index.

A COCOA ESTATE

The cocoa estate of 323 cultivated acres is a commercial venture operated by a private company which has access to good accounting facilities. The accounting previous to the formation of the company was traditional to Trinidad cocoa estates and consisted of preparing an ' abstract ' of the labour operations together with certain other details each fortnight; the fortnight's wages were drawn on the authority of this document. The scope of the card accounting has not developed quite to the extent the writer and the estate manager would like because some directors insist on maintaining the tradition, while others insist equally strongly on orthodox financial accounting. Although all the transactions necessary for full accounting are not carded, they would add little to the numbers used or the work involved; they are not included because they merely duplicate what would continue to be kept by the accountants.

The present card accounts consist of elaborate labour analyses and information as to yields, clones planted, manures applied, *etc* ; the classification is divided into 33 fields and ten field operations. The justification for such elaborate analysis is that a systematic programme of field improvement with clonal cocoa is in progress so that field as well as operational accounts are of importance. The coding of the cultural operations, 875 in the detail section on the right hand side of *Figure 3*, is arranged so that improvement operations (' preparation for planting ', ' planting cocoa ', *etc*) can be quickly separated from upkeep operations (' field maintenance ', ' harvesting cocoa ', *etc*). These cards give information on the labour cost of different methods of improvement and the variation in the improvement in field performance according to method and other characteristics of the field. Such is essential information for the efficient management of an expensive improvement programme on a virtually one crop estate.

Theoretically the most interesting feature of these accounts is that all the original entries are made on the estate and the estate manager much prefers the card procedure to the traditional, much less informative, abstract that he is also required to prepare. He is supplied with two types of card, one to

accommodate gang work (*Figure 3*) and one for regular workers whose occupations do not vary. Both types are bound in duplicate books, the card being a carbon copy of the top sheet which is retained as a permanent record on the estate. The cards, consisting of about 150 a fortnight, are mailed regularly for clipping and analysis which occupies one assistant about four hours. A fortnightly statement is prepared field by field together with operational totals for the whole estate; the annual statement is prepared direct from the cards.

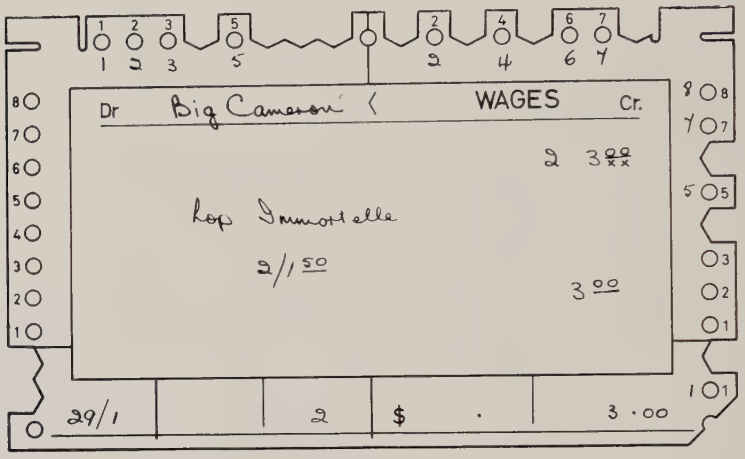

Figure 3

THE DAIRY FARM

The dairy farm run by the Government of Trinidad and Tobago consists of a herd that may milk as many as 170 cows a year; in addition there are many other small enterprises. The farm has proved an excellent test of the system for both volume and complexity—volume chiefly in regard to the accounting of milk, and complexity in regard to the management of concentrated feeding stuffs. The milk recording, the start of milk accounting, had always proved laborious when kept in books; with the card accounts these records have been reduced to a simple routine which requires the minimum of clerical work. Before the beginning of the farming year account cards similar to that shown in *Figure 4* are prepared and pre-clipped (Dr Dairy Herd (2357) < (Dairy Cows (2345) Cr.) for every cow in the herd at the end of the year, one card per cow for each milking each month; other sets are added as new cows come into the herd. The identification of more than 70 cows in the detail perforations involves cross coding, the full coding for Magdalena 4 being 1/8765. The appropriate month's cards are pinned to display boards, one for morning and one for afternoon milking, which are hung in the dairy. The weight of milk obtained is recorded by the cowman on these boards and the standard ruling on the card provides ample space for the satisfactory entry in the rather rough conditions of the dairy. The daily totals (Dr Milk Production (2356) < (Dairy Herd (2357) Cr.) are also prepared by the cowman and are balanced with transactions for the disposal

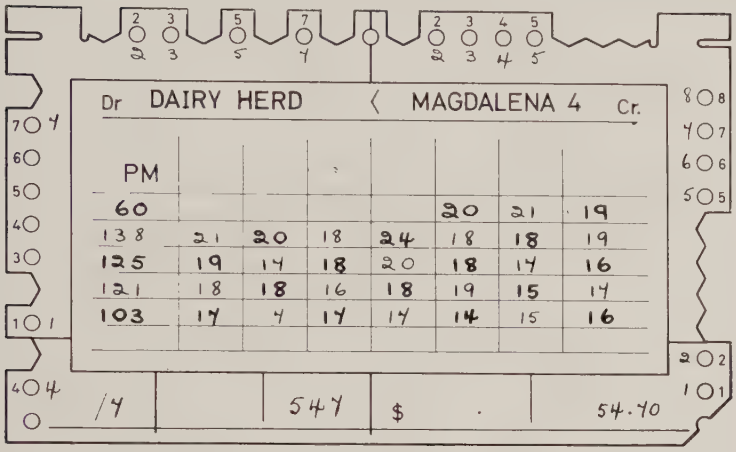

Figure 4

of milk, *e.g.* Dr Sale of Milk (1257) < Milk Production (2356) Cr. In a year about 90,000 milk account entries are handled on some 3,000 cards.

The summary of the performance of individual cows is made on the valuation card of the animal at the end of the year (see *Figure 5*). Since lactation as well as annual production is required, that part of a lactation completed in the current year that was produced in the previous year is copied off (in the column headed '51 in *Figure 5*); the current year's production is split into the completion of this lactation and the remainder. To obtain the current year's total production (5268 lb. in 321 days) the two right hand columns are added; to obtain the completed lactation the two left hand columns are added (6102 lb. in 351 days). For herd selection purposes yields are also totalled for the first 305 days of completed lactation (5637 lb.). These cards allow a compact summary to be made of the performance of the whole herd (*Table 1*) with very little labour because each cow can be coded for the class into which she falls; code 87 in the details

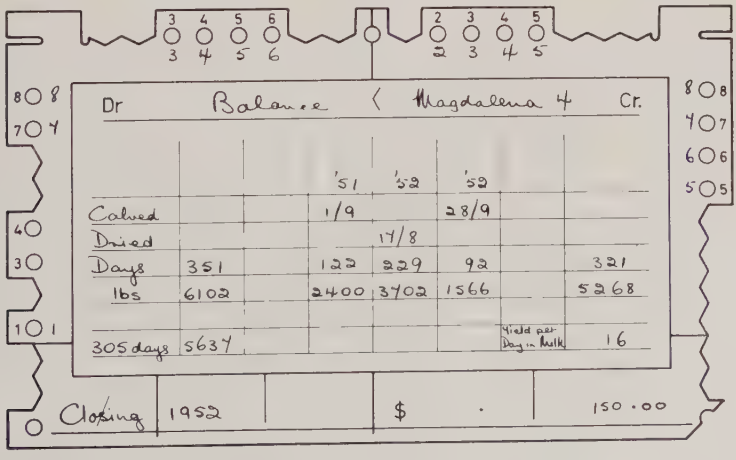

Figure 5

on the debit side of *Figure 5* indicates that this cow was full time in the herd and over 200 days in milk.

Table 1. Herd production, 1952

	No. of cows	*Days in Herd*	*Days in Milk*	*Total Yield lb.*	*Yield per cow gal.*
Full time cows:					
200 days in milk & over	76	27,740	22,413	543,689	698
Less than 200 days ..	9	3,285	849	18,599	202
Total full time cows ..	85	31,025	23,262	562,288	645
Part time cows:					
Part-year cows	2	93	93	1,789	87
Heifers in	12	2,452	2,452	75,534	614
Heifers in and out ..	2	482	482	17,731	855
Total part time cows ..	16	3,027	3,027	94,854	578
All animals	101	34,052	26,289	657,142	635

Information regarding births and services are kept by the stockmen supervising these events. Books of tab cards are prepared for their use and prove to be quite as durable and considerably more handy than ordinary field notebooks. *Figure 6* shows a service originally entered by the stockman and subsequently classified as a ' good re-service '. The service cards are used to summarize the breeding performance of both cows and bulls. These and all other cards (some 500 a month in two of 48 different accounts) are ' trial balanced ' at monthly intervals in the normal way.

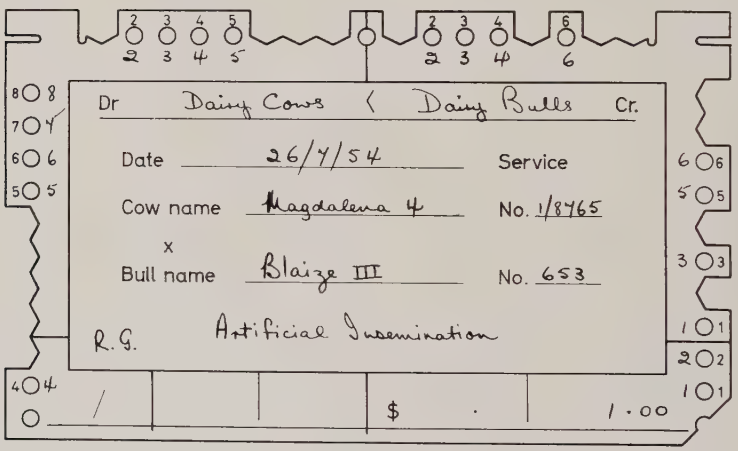

Figure 6

The handling of concentrated feeding stuffs on this farm is complex; as many as 12 different kinds are purchased and mixed into various rations which are issued to about 20 different types of consumers including various government breeding units scattered through the island. Altogether about 260 tons of concentrates costing $24,000 go through the feed store in a year. Control is obtained by tracing the movement of feeding stuffs as they actually occur. The transaction usually starts with a purchase recorded on a card similar to that shown in *Figure 1*; according to its movement in the store part of this purchase can be issued to feed ingredients account, then to a

feed mixing account, then to rations account and finally to a consumer's account. It is possible therefore to trace discrepancies at every stage of the manipulation, and with practice excellent control is obtained. One problem, common to all complicated stores accounts on a farm, is the variation and awkwardness of unit prices; these feed transactions have demonstrated clearly the value of using convenient working prices for internal transactions and carrying away awkward differences to a price adjustment account. Periodically the balance on price adjustment in respect of feeding stuffs accounts is apportioned to the consumers according to the preliminary charges.

DISTRICT AGRICULTURAL STATION

A recent undertaking is the accounting of a district station of the Trinidad Department of Agriculture. The station serves various functions and includes many activities, some of which are supposedly commercial. About 50 labourers are employed and time sheets and other standard documents required by the Treasury are prepared. The only agricultural summary prepared for this station prior to the introduction of the cards was a three-monthly abstract of labour expenditure and income on various sections, numbers of livestock, rainfall and other particulars; none of these, however, was related directly to the Treasury accounts. It is hoped that this pioneer project can eventually act as a model for other district stations.

At present these card accounts are of interest in two respects; first, they have demonstrated the understandable inadequacy of public accounting for this type of enterprise where technical efficiency is under question or is being investigated. The treasury accountant is primarily concerned with the legality of the expenditure of public funds, whereas the officer-in-charge is concerned with the efficiency of the expenditure he is empowered to authorize. Without a fairly elaborate agricultural breakdown of the public accounts the officer has little or no guidance with his technical problems. The card accounting of this station is intended to fulfil the legal requirements and at the same time throw up a wealth of accounting information on the agricultural efficiency of the station.

The second point of interest is the complete control of labour accounts using pay cards for each worker. These cards carry information for individual workers for all the fortnightly pay periods that fall within the month; these should be more useful than the ordinary pay list (which can rapidly be prepared from a card if required) because the cards can be filed by individual worker and can be entered with his accumulated performance. Suppose the worker illustrated in *Figure 7* is entitled to sick and holiday leave only after completing 250 days, his absence in the first fortnight cannot be taken as leave, but in the last fortnight it can. At the end of the month he has worked 264 days and has taken 3 days' holiday and 1 day's sick leave out of his entitlement. It is found most convenient to note his gross daily wage, overtime being shown by a +, and to deduct any contribution to a Provident or other fund at the end of the appropriate fortnights. The total of such deductions are shown on a separate card, Dr Wages (1258) Provident Fund (3457) Cr. Gross wages are reconciled with wage allocations to enterprises fortnightly and because of the variation of individuals' rates these allocations are at working prices using the price adjustment account. The

accounts are trial balanced monthly in the normal way and, when a fortnight runs over the month, wage balance cards are introduced to make wages a self-balancing account.

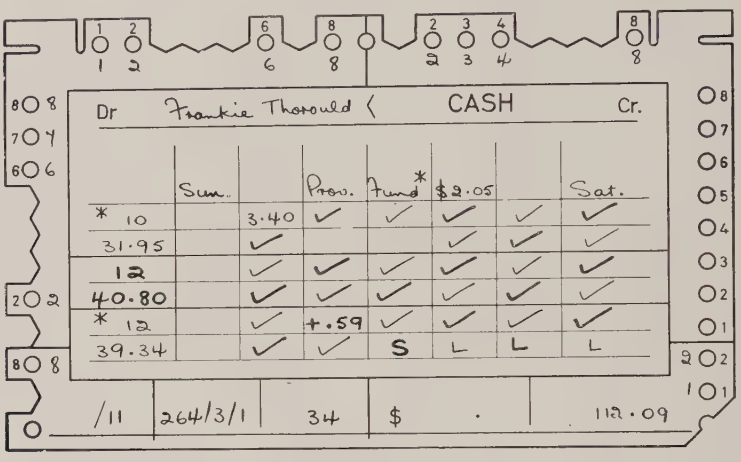

Figure 7

CONCLUSION

So far no effort has been made to apply the system to any really large scale undertaking and it is doubtful if such a trial would be profitable. A business the size of, for example, a sugar estate can specialize its accounting and avail itself of the most suitable of the wide variety of accounting machines on the market to-day. Clip-cards would probably prove unwieldy and their simplicity would be no advantage. Neither has an attempt been made to produce the minimum financial accounts for a farm by the system. There might be some possibilities in such skeleton accounts particularly as they would form a foundation on which more elaborate accounts could grow. Such skeleton accounts are, however, kept by the writer for his domestic affairs which require only 18 accounts (with no details) and about 30 cards a month; the discipline has had a healthy effect on his personal finances ! Nevertheless, the system is likely to prove most useful on the medium sized farm and particularly where the farmer has to keep the accounts as well as run the farm.

The system has now evolved as far as is likely by experiment alone; the present need is for more practical commercial application if it is to prove its merit. The author would therefore be glad to assist and advise interested agriculturists on the most suitable accounting schemes and the most labour-saving card procedures for their own particular circumstances. He can provide initial supplies of cards and the other simple equipment required at cost to anyone seriously taking up the system.

(*Received March 1956*)

REFERENCES

[1] JOLLY, A. L. (1951). Clip-Card Accounting on the Farm. *Trop. Agriculture, Trin.*, **28,** 46
[2] — (1953). *Clip-Card Accounting on the Farm.* Imperial College of Tropical Agriculture
[3] — (1954). *Peasant Farming: Report on Peasant Experimental Farms at the Imperial College of Tropical Agriculture, Trinidad, B.W.I.* Central Secretariat, Caribbean Commission

Some Current Problems of African Land Tenure

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The aim of this paper is not to cover the entire ground of the complex problems with which African land tenure is beset, but to attempt to delineate the trends of certain significant developments in the practice of husbandry and in the nature and extent of customary land rights. The approach will therefore be more analytical than expository. It is hoped that it may help those concerned with practical problems of land administration and agricultural development to obtain a bird's eye view of the changes in the landscape as a whole, so that related issues may be thought of together when plans are being made for specific projects. The subject may be considered under the following three heads.

FACTORS AFFECTING TRADITIONAL TENURE

Land tenure in most parts of Africa is closely bound up with the ubiquitous institution of chieftaincy. The chief's traditional authority over land, as over much else, is on the wane. No longer is he the final arbiter in land disputes; his rights to allocate and re-allocate portions of community land to needy family heads as well as his right to the ultimate reversion of land no longer required by former grantees are becoming more and more shadowy. The same is true, though to a much more limited extent, of the family head's analogous powers over family land. In areas without a system of traditional chieftaincy, the role of the chief is played by a council of elders, though in a more restricted and less definitive manner. The irony, however, is that the chief is nowadays usually a chief-in-council and no longer a ' sole native authority ' in respect of his administrative duties, including those affecting dealings in land in his area.

This whole process is, however, not as marked in societies that have been little affected by disturbing external influences, as in those that have had the indigenous character of land-holding seriously disorganized or modified. Thus the British West African territories have to a large extent retained the traditional patterns of tenure, particularly in the rural areas, which are happily much the greater part of each territory. The same is probably true of the non-industrial areas of Northern Rhodesia, Nyasaland, and parts of Tanganyika. But the presence of settlers in Central and East Africa has introduced a new dimension into the characteristics of land-holding and, perforce, of agricultural practices in these parts. It has meant, for instance, the introduction of the western concept of ownership as distinct from possession, of individual ownership of land as opposed to corporate holding by family or extended family, of alienability of land and the consequent commercialization of land rights by members of the owning family. Probably

the most significant factor in this respect has been the creation of land reserves respectively for the aboriginal and the immigrant inhabitants of these areas. Now the traditional African system of land holding and land use is expansive rather than intensive; the economy is one of subsistence, there being little need of cash crops and the attendant commercial exploitation of land. Under the system of shifting cultivation, plenty of land space is essential for the proper use of fallow. It can therefore be seen how the creation of ' native reserves ' has limited the area of operation of the indigenous system of husbandry and, inevitably, of the social and economic structure of the peoples.

But even in Uganda, a territory almost entirely free from European settlement, land tenure has undergone a radical transformation of another kind. When at the turn of the century the territory was declared a British Protectorate, much uncertainty no doubt existed both as to the nature of indigenous titles to land and as to the extent of individual or group holdings including the various uses to which these could be put. The remedy provided by the Uganda Agreement of 1900 was to survey and then demarcate the land into specific holdings since known as *mailo* lands—a curious hotchpotch of largely European notions and usages and to a lesser extent of African ideas and customs. The result has been the wholesale importation of the alien concept and practice of the landlord and tenant relationship akin to that which, at a similar stage in India, caused the virtual dispossession of immemorial peasant owner-occupiers and the substitution of a new class of landlords—the *Zamindari* class, often absentees –who had no traditional claim or pretention to the prerogatives then bestowed upon them. In Uganda, as in India, the problems thus unwittingly created are now being faced.

In British West Africa, no such drastic step has been taken to interfere with the indigenous system of tenure, and there have been no European settlement or plantations to complicate the picture. The reason is partly because West African societies have evolved rather larger political units which have survived into the era of European contact and penetration; this has meant a profusion of larger group land areas than are to be found in Central and East Africa. It is a notorious fact that West Africans have evolved as part of their social structure the system of living in villages and towns, whereas scattered homesteads over often beautiful country have characterized the social arrangements of most of the Central and East Africans. The relevance of this point is that the pattern of agriculture often depends upon such political and social distinctions. West African agriculture has lent itself to the development of relatively large farms and to a certain amount of sophistication in the internal exchange of farm produce as between village and village and town and town. These farms are often located at some distance from the inhabited (or urban) areas, while domestic ' gardens ' are also cultivated, sometimes side by side with the large farms and sometimes nearer their cultivators' dwellings. In Central and East Africa, on the other hand, the common pattern and almost the largest units of indigenous agriculture are the ' gardens ', often to be found attached to homesteads or little clusters of these.

The second and probably the major reason why West African land tenure has been so little affected by external influences has been the protective

policy of the British administration against the acquisitive tendencies alike of African chiefs and of European investors during a critical stage of evolution of the west coast. Thus, when prospectors and ' concession hunters ' were menacing the established land tenure system Sir WILLIAM MAXWELL, then Governor of the Gold Coast, introducing a Land Bill in 1897 in the Legislative Council said: ' Native chiefs cannot be permitted to deal uncontrolled with public rights, and the transactions by which it is alleged that private rights have been created over public land, in a manner wholly unknown to the native tenure of West African tribes, require examination and possibly extensive modification '.

The aim of this Bill was to make it impossible for the chiefs to deal with family or community land as if they were the absolute fee simple owners and so entitled to pocket the proceeds of alienation of the land or its products to alien investors, who were naturally looking for absolute owners of the land in their accustomed European sense. The Bill was, however, not passed by the Legislative Council because both chiefs and politicians opposed it, though for different reasons; the chiefs because it would deny them a source of ill-gotten wealth, and the politicians because they feared that the administration, as the prime mover of the Bill, might ultimately gain complete control of Gold Coast land. A somewhat similar issue faced Nigeria in 1924. Lord LEVERHULME, in a speech before the Liverpool Chamber of Commerce in July of that year, said that he had no doubt that ' in the cultivation of plantations there must be some security of tenure on land . . . But somehow or other our politicians . . . have for many years now viewed the African from an entirely different standpoint . . . Capital will not flow without security . . . The African native will be happier . . . when his labour is directed by his white brother '. But far-sighted men like Sir HUGH CLIFFORD, who as Governor has had wide administrative experience in both the Gold Coast and Nigeria, were staunch in their opposition to the idea that limited liability companies should be permitted by the government to establish plantations for the production of palm oil and palm kernels in Nigeria. In his address to the Legislative Council on 6 February, 1925, Sir Hugh said: ' It is my earnest hope that the land policy of the Government, which in my judgement is the corner stone upon which the entire edifice of native prosperity . . . depends, will never be suffered to be altered or abandoned, no matter how strongly it may be urged that such action is demanded in the name of economic expediency '. It is interesting to speculate what Sir Hugh Clifford's reaction would have been to certain of the recommendations in the recent Royal Commission's report on East Africa.

In spite of the failure of the 1897 Land Bill in the Gold Coast, the real powers and liabilities of the chiefs in relation to land have been progressively defined in a series of judicial decisions, probably the most authoritative of which is the well-known case of *Amodu Tijani* v. *Secretary, Southern Nigeria* (1921). Their Lordships of the Privy Council lay it down that chiefs are trustees or caretakers or guardians, call it what you will, of the corporate land over which they have rights of allocation and reversion on behalf of the family or community who are the ultimate ' owners ' of the land; that, accordingly, all compensation awards or proceeds of sale or lease of such

land belong to the entire family or community, among whom they must be shared; and that the customary land tenure knows nothing in the nature of an absolute fee simple ownership of land, such as some chiefs had been in the habit of claiming to possess *vis-à-vis* alien investors and speculators. This decision has since been taken to epitomize the main principles of law relating to this subject, and has been universally applied to other colonial territories, including for instance Maori lands in New Zealand in 1941.

Equally, the protective policy against alienation of land subject to customary tenure to non-Africans has not been carried so far as to preclude all forms of regulated and beneficial exploitation of land. In all the four British territories in West Africa the alienation of land to non-Africans without the Governor's consent is forbidden by law. The largest quantum of interest in land that an alien can acquire in West Africa is normally a lease for 99 years. In some areas, as in the Gold Coast, there exists legislation providing that any grant of land or of mineral or other products of land by an African which involves a minimum area of five acres to a non-African or 25 acres to another African must be submitted to a judicial enquiry. In such cases, the court of enquiry is requested to ensure that the customary rights of the African inhabitants of the area concerned are duly protected, and that a fair and just bargain has been made between the parties.

INDIVIDUALIZATION OF LAND RIGHTS

European contact with West, Central, and East Africa has not only had the direct physical effects (resulting, *e.g.* from administration and settlement) which have just been described, but has also brought about a number of equally important changes in the traditional modes and attitudes of the African towards his land. The growing idea of individualization of rights in land traditionally held on family, community, or corporate tenure is a problem of some concern. It is a common feature of all types of African land tenure that ' ownership ' is ordinarily never vested in an individual but in a group; this group may be the family or extended family, or it may be a village consisting of a congeries of related families or lineages. Within each such group, however, individual members have specific portions allotted to them by the family head, in much the same way as the local chief allots—at least notionally—specific parcels of the village land to the constituent family heads according to need. In either case, there are usually reserved areas of such land to meet the future requirements of a growing family or community. A cardinal principle of all these allotments is that no individual allottee may alienate his portion without the consent of his family or at least of all the principal members of it. No valid title can therefore be acquired by a purchaser from an individual allottee of family land. While his allotment lasts, however, he enjoys virtually all the plenitude of powers of cultivation and use that an absolute owner enjoys over his land in western countries. He can grant a short and temporary loan or lease of it to an outsider within the community, and at his death his holding is heritable by his own children.

One significant point seems to stand out from the foregoing. It is that land, once allocated by a chief to family heads, tends to pass out of his ken and can be dealt with by the family collectively as its members please without

any further interference on the chief's part until such land is either abandoned or the allottee family are collectively guilty of outrageous conduct incurring a forfeiture of the entire holding. Whereas the family as such tends to be free in practice to dispose of family land, the individual does not enjoy a similar right; he continues to be subject to the ultimate sanctions of the family so long as his allotment remains part of family land under customary tenure. In a subsistence economy where land constitutes the main and often the only source of wealth for the owning group, this is an understandable scheme of social insurance against possible improvidence on the part of members of the group. But the introduction of a cash economy, mainly though not exclusively through European contact, has introduced new ideas into the customary concepts of tenure in all parts of the continent. The dynamics of change in traditional tenure towards the individualization of land rights may be observed at work in a number of ways, of which the following seem to be the most important.

(*a*) *Right of first cultivation*—When discussing the corporate nature of landholding in Africa and particularly the chief's role of allocator and reversionary on behalf of the local group, it is not often realized that from the earliest times this apparently hide-bound system has allowed for the right of individual acquisition of any part of the virgin bush or forest not hitherto associated with any known community, family, or individual. It was only thus in the past that new settlements could have been formed by those seeking new homes, either for the mere love of adventure, or because of political persecution, expulsion from the tribe for grave crimes, overcrowding, and the like. Whatever the reason for such first cultivation or acquisition, the theory has been established that the parcel of land belongs to him who first cultivates it in the circumstances just described. This means that it is entirely his to do with as he pleases—to sell or lease or even pledge, without any family restraint or inhibition. But his children inherit such individually owned land as *family* property, possessing all the characteristics of customary tenure—unless he disposes of it otherwise in his lifetime or by will.

(*b*) *Partition by joint inheritors*—The principle is that family land may be converted into individual holdings by the partitioning of it among all the members entitled. This may take place at a family conclave or it may be ordered by a court following an appeal to it from one or more of the members of the family. It is interesting to note that the share of anyone under such a partition has been held by the court to be in the nature of an absolute estate of freehold under English law (*Balogun* v. *Balogun*, 1943, a decision of the West African Court of Appeal). Of course, neither the family nor the court will lightly order partition unless as a last resort, *i.e.* where it is found to be both desirable and inevitable in the interests of all concerned.

(*c*) *Fragmentation of land holdings*—One of the greatest arguments against the customary rules of inheritance and succession in Africa is that they often lead to uneconomic fragmentation of holdings. This is all the more so in areas that have not known large and extensive farms or even urban lands to be usually held by the individual or the family. Where all that has to be split up among the inheriting children and other relations is a medium sized farm or building, the danger of fragmentation is obvious. Even where the patrimony to be shared is large and the individual's partitioned lot is

economically viable, a stage is soon reached, probably in the second or third generation, at which further subdivision is out of the question. Fortunately it is precisely at this point that the courts, when they have a chance to deal with the matter, step in to order sale instead of partition, the proceeds being shared instead among those entitled. This situation would hardly have arisen frequently in the past, when there was almost always so much extra land available and individual needs were so often elementary.

(*d*) *Appointment of 'statutory' heirs*—In many other countries faced with the problem of excessive subdivision of land resulting from customary rules of inheritance and succession, it has been found that the practice of the courts to order sale in suitable cases is not usually sufficient, as only a minor proportion of disputed issues of succession ever come before the court. The vast majority of people continue to divide group land into often uneconomic units in accordance with the rulings of immemorial custom. One way out that is being tried, for example in Ceylon, is the institution of one of the entitled beneficiaries as 'heir' to the patrimony so that the land devolves upon him alone as owner, free from the competing claims of collaterals as well as of brothers and sisters. The 'heir' will of course have to compensate all the others according to their customary rights after a proper valuation of all the land and buildings comprised in the property. Where necessary, the state will come to the aid of an heir with inadequate personal resources to meet the claims of the others; an arrangement will then be entered into between the heir and the state for repayment of such loan and, probably, for the better and more economical development of the land concerned. This is to be highly commended as a worthwhile contribution to the solution of excessive fragmentation of land but it seems at least doubtful how far group members can easily agree as to the choice of one of themselves as heir and, even when that problem has been resolved (as it may well be, especially in patrilineal societies or those few that have a system of primogeniture or of ultimogeniture), how far the chosen heir will be willing to approach whatever statutory body has been set up to deal with relevant applications. The only way to obviate these difficulties is to decree by legislation a system of compulsory institution of heir in all cases where 'owners' of land die intestate. It may be that such a course might be feasible in a country like Ceylon with a tradition of Roman–Dutch law and its established idea of the institution of heir; it might not be easy to apply elsewhere, obviously because of a different social experience and economic order.

(*e*) *Acquisition of individual titles by purchase*—As will be clear to the reader, any one of the four processes outlined above will result in individualization of the holdings of each of the original occupiers. If this, his new interest, is transferred to a purchaser, the courts have taken the line that only an absolute estate of freehold can be regarded as having passed to him. Such an absolute title, like the analogous one acquired by each of the methods indicated in *a* to *d*, will however devolve in due course upon the successors to the original purchaser as family property, unless he has otherwise disposed of the land by will or has married in one of the ways prescribed by the local Ordinance (*i.e.* in accordance with English law).

(*f*) *Parcelling up and demarcation of group lands*—Yet one more agency promoting the individualization of land holdings is the growing practice,

begun with such early experiments as the creation of the so-called *mailo* lands in Uganda, whereby formerly group lands are being broken up into regulated individual acreages. This process has been continuing for some time now and has been given added impetus by the second World War, no less than by the impact of European settlement. That is why it has been confined almost entirely to the East and Central African territories. To take only one example, the whole land area of the Kipsigis who inhabit part of the Nyanza Province of Kenya has practically been turned into individual holdings, some 3/4 of which have been demarcated by hedges and enclosed sometimes by planted trees, sometimes by barbed wire, at other times by Mauritius thorn. It has been claimed that this individualization of land rights has led to stock limitation by the 'squeeze method' which, by restricting the area of stock grazing, compels the family to make over its surplus stock to lineage members in less enclosed areas or to sell them in the open market. But the success of this scheme implies the existence of nearby unenclosed areas. Does not this show that the process can be fully introduced only into certain types of land areas ? What will become of each of these small enclosed fields when the family head dies and the land comes to be inherited by a number of his children? Unless legislation is passed to regulate the mode of inheritance and succession, it is difficult to see how these enclosures can escape the peril of fragmentation through customary descent.

(*g*) *Consolidation of scattered holdings*—The reverse process to that outlined in *f* above is the practice, at the instance of the administration, of consolidating the scattered holdings which a person has in different parts of the same area into one sizeable or economic farming unit. Again, Kenya supplies an obvious example, this time in Kikuyu country. Fragmentation resulting from inheritance laws has been the motive force impelling this change. But since, as in *f*, the issue of land titles to the individual holders is the objective, the basic problem remains of how to prevent a regression taking place on the death intestate of the original holder, whose successors might want to fragment it again into separate shares. Although resolutions may have been passed forbidding such excessive subdivisions of land already consolidated, it is nevertheless highly improbable that anything short of central legislation enforceable in the courts will stop people dividing up such land later.

AGRARIAN PLANNING AND INDUSTRIALIZATION

Because of the difficulties and problems underlying the customary tenure systems, various methods of improving African agriculture have been suggested by experts. Many have advocated the introduction and encouragement of a large-scale system of enclosure and resettlement of land, while others seem to have favoured gradual and evolutionary development through cooperative farming as the best line of advance. Probably the most interesting recent exposition of the first view is that expressed by D. C. Igwe[1], while the opposite case has been ably put by J. Gordon[2]. Both are practical suggestions towards solving a difficult problem by serving officers. One has served, and the other is still serving, in West Africa, and each has brought a certain amount of realism into the discussion. If, therefore, one tends to

favour the evolutionist rather than the radical reformer, one must be forgiven for taking sides. The best scheme might be one based on some such motto as: cooperative farming wherever we can have it, small-scale enclosed farming where we must have it—but in all cases, orderly development and social welfare should keep pace together.

The virtues of certainty of land titles and of security of tenure which have been rightly claimed to accompany the enclosure movement in sixteenth century England are worth stressing in the present context of African agriculture. However, the attendant economic and social miseries of the dispossessed and penurious peasantry, a chaos that was not relieved by the almost simultaneous development of the woollen industry should not be forgotten. Economic historians tell us that there was a necessary connection between the enclosure movement of the eighteenth century, the logical culmination of the process set in motion in the sixteenth century, and the workhouse—of whose stark realities CHARLES DICKENS has made us all so painfully aware.

Already, the limited consolidation of holdings that is taking place in Kikuyu country, like the demarcation and enclosure of lands that have been going on among the Kipsigis and in parts of the Rhodesias, are beginning to raise agrarian problems which the enthusiasts for these schemes would do well to stop and ponder. It must not be forgotten that all these things are happening mostly within the so-called native reserves of these parts of Africa. If a system of enclosure and resettlement were to be undertaken in Nigeria, many factors would have to be taken into account. Sociological fieldwork would need to be carried out district by district in order to discover the nature and extent of land holdings by individuals and families, and which lands are subject to what indigenous third-party rights arising from such practices as the ' borrowing ' of land, perpetually redeemable pledges of land, *ishakole* and *kola* tenancies, lands held in widely-separated villages by members of exogamous lineages, and similar other special customs and usages. Unless and until these and other incidents of customary tenure are carefully sorted out and recorded, consolidation or enclosure can only result in grave confusion and injustice in most areas. Very large and miscellaneous categories of staff trained in different disciplines would have to be deployed in the field to tackle the problems.

The problems of enclosure would be particularly acute in such areas of dense population as most of Eastern Nigeria and parts of Western Nigeria. On the other hand, cooperative farming should not present anything like the same number of intractable problems. After all, the present tenurial systems in both Nigeria and the Gold Coast have been able to sustain the development of cocoa, groundnut, and cotton farming on a fairly large scale. It must be profitable to try to find out why, and to consider whether it is possible to apply the lesson to other types of agricultural development.

Similarly, we should do well to take note of such schemes as the Mokwa agricultural project in Northern Nigeria, the Gonja scheme in the Gold Coast, the Gambian poultry and East African groundnut schemes, or the Cameroons Development Corporation's agricultural projects. How was land secured for all these agricultural experiments ? What were the objectives ? . The Cameroons Development Corporation was a statutory

body set up by the Nigerian government with an initial capital of £1,750,000. The Corporation took over in 1948 the ex-enemy plantations in the Cameroons, and the land was vested jointly in the people of the Cameroons and the Board, the enterprise thereby representing the partnership of Government, business experience, and the people of the area. There is a provision that all profits must be used for further research and development as well as for ' the welfare and common benefit of the people of the Cameroons '. It is one of the successful types of modern approach to the problems of agricultural development and welfare. In addition, a sum of £60,000 went to a government-controlled prospecting company in the Cameroons within a few years of the Corporation's establishment.

The Mokwa agricultural project in Nigeria was based on capital supplied partly by the Colonial Development Corporation and partly by the Nigerian government, with the local authority of the area providing the land and the requisite labour force. The failure of the project, which has recently had to be taken over by the local authority when the C.D.C. withdrew its share of the capital, was due in no small measure to the welfare nature of the preliminary social services and the large-scale clearance and settlement expenditure with which it was burdened from the start. The kind of initial planning of the economic resources and long term forecast of the commercial possibilities, which alone could have made the famous Gezira scheme in the Sudan feasible, seemed to be lacking at the most crucial stage of the launching of the project. However, the more satisfactory position, at least until recently, of the Gonja scheme in the Gold Coast gives ground for hope that careful planning and intelligent execution can make similar undertakings both practicable and beneficial. Indeed, several schemes of large-scale development or economic investment involving land in West Africa are now being undertaken by an alliance between the Government and foreign investors in procuring the needed capital and technical ability, while the local authority of the area of the scheme provides the land and the labour force. This shows that the existing forms of customary tenure are not so necessarily unamenable to modern requirements of large-scale agricultural development.

Besides these projects in which the West African colonial governments participate, there are a number of foreign companies and individuals carrying out independent operations like the Sapele Saw Mills Ltd in Nigeria or the Sierra Leone Selection Trust Ltd which holds a monopoly for the exploration and production of diamonds over most of Sierra Leone. All such private concessions are a matter of individual negotiation between the investors or prospectors and the local authorities of the area concerned, subject of course to the central Government's formal consent in proper cases. Whatever might be the inhibiting features of the customary land tenure, development need not be hampered nor foreign investors deterred if the project is channelled through the agency of the relevant local authority.

Nevertheless, the basic problems remain of how the African occupiers and cultivators can put their land to more productive use without at the same time being subjected to the difficulties which indiscriminate demarcation and enclosure of group lands might entail. An encouraging example of the value of exploiting the traditional forms of cooperative labour among

Africans is that so well described for the Gusii by P. MAYER[3]. It is a fascinating story of the conscious stimulation by the administration of cooperative farming among this African people of Kenya. Before embarking on any large-scale enclosure movement, efforts should be made to try this experiment in cooperative farming elsewhere, even if on a limited or modified scale to begin with. Ultimately, the resulting large farms may have to be sold and the cooperators dispersed, but industry should have developed sufficiently by then to absorb those who sell out their interests.

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REFERENCES

[1] IGWE, D. C. (1954). The Need for Enclosure and Land Resettlement in Nigerian Agriculture. *Trop. Agriculture, Trin.*, **31,** 57

[2] GORDON, J. (1954). Enclosure and Land Settlement and the Evolution of West African Agriculture. *ibid* **31,** 303

[3] MAYER, P. (1951). *Two Studies in Applied Anthropology in Kenya*, Colonial Research Studies No. 3, Her Majesty's Stationery Office: London

*Wild Coffee in Kaffa Province of Ethiopia**

H. von Strenge

Jimma, Ethiopia

South-west of Addis Ababa, the capital of Ethiopia, lies the province of Kaffa, between 6° and 8° N latitude and between 35° and 37° E longitude. The country is very mountainous and there are numerous rivers and streams which dissect the landscape deeply. Altitudes vary from 3000 to 10,000 ft; the rainfall is from 50 to 100 in./year. The driest months are from November to March inclusive, but there is hardly ever a month without some rainfall. The soils are almost entirely tropical red earths of varying depth. There are in addition black soils and very soft sandy ones, on which coffee also grows; even on shallow stony soils coffee can often be found growing relatively well.

The population outside the few larger townships consists principally of Cushitic people, who carry on cultivation and stock-raising. The Kaffa region, especially its southern part, is forest country, but wherever the inhabitants have settled more thickly, and especially in the neighbourhood of Jimma, large areas have in the course of time been deforested and are planted with coffee. The characteristic of the Kaffa forests is the great wealth of species in tall-stemmed trees. The forests lack regular outlines, throughout them tall trees are intermixed with shorter ones. Trees with spreading buttress roots, which give place above to a smooth slender trunk, are common. Often four or five levels of shrub and tree crowns are superimposed on each other, and are linked together by liana stems as thick as an arm. A typical representative is the strangler fig (*Ficus* sp.), which starts as a liana clinging to the host tree, surrounds this in the course of time with ever increasing tentacles, and finally forms a trunk in which the original tree, now dead, is enclosed.

Large glossy surfaced leaves, often with drip tips, give the forests a characteristic appearance. Here and there may be found groups of arborescent Euphorbiaceae, as well as numerous climbing species of this family, while everywhere the characteristic growth of creepers with many sided spines and thorns penetrates the forest, especially near ground level. *Dracaena* plants form a dense tangled undergrowth, or stand singly in the arborescent species of this genus. In moist places and where there is more light palms (*Phoenix abyssinica*) stand. The ground layer is composed of numerous herbaceous plants, or grasses in the lighter places. Epiphytes of all kinds, ground and tree-growing ferns, mosses and liverworts are richly represented. Pendulous lichens occur mainly at the upper levels. In places, a variety of species of *Aframomum* are found, covering wide areas or forming dense thickets.

*Translated, by permission, from *Der Deutsche Kulturpionier* 56 (1955).

These forests are in all probability the original habitat of *Coffea arabica*. The places where truly wild coffee is still to be found are, however, limited to the small areas of primary forest which still survive. Nowadays the greater part of the Kaffa forests are secondary. So-called ' wild ' coffee is also found in these. The question however arises whether this is really wild coffee—that is coffee bushes derived from wild stands in the primary forest, which have survived its thinning or from some cause escaped clearance—or whether it is secondarily wild coffee, which was planted when these areas were settled and cultivated, and then remained when the settlements were again abandoned.

The following observations throw light upon this problem. Sixty years ago Kaffa was an independent kingdom, which closed its borders almost hermetically against the surrounding provinces of the Ethiopian empire. In 1897 the kingdom of Kaffa was overthrown by the Emperor Menelik II, and the country largely depopulated as a result of the bitter fighting.

Old settlement sites, which are now of course completely overgrown are found everywhere throughout the extensive forests. They prove however that this region was at one time thickly settled. In numerous places, often only a few yards apart, stand candelabra *Euphorbia*, which were originally planted as fences round the huts. These are interspersed with dense thickets of *Dracaena*, which also served as hedges. One can be sure of finding also in such places the ancient grinding-stones, with which the inhabitants of Kaffa still grist their meal; and it is in these places that coffee trees are also found. This is not surprising because the people still plant coffee trees round their huts today. With the abandonment of the settlements, the forest again took possession of its old territory; through the agency of monkeys and of floods, the coffee then became dispersed from such centres to greater or shorter distances. Floods are a means of dispersal particularly from positions on slopes; then the area of dispersal takes an elongated form down the slope, with the older trees standing in the higher positions. It can almost always be observed that the stand of coffee derives from one or more particular mother trees.

True wild coffee, then, is found only in primary forest. There is every ground for the belief that Ethiopia is the original home of coffee, which is confirmed by the fact that within small areas four or more genetically different types of coffee tree can be found. '*Coffea aethiopica*' would therefore have been a more correct name than *Coffea arabica*.

There has been some discussion whether the name of the beverage, ' Kaffee ', 'Café ', ' Coffee ', is derived from Kaffa, the home of the coffee tree. Many scholars doubt this, because here in Kaffa the infusion is known as *Buna*. In my view one must take into account that the region, from which the Arabs obtained coffee centuries ago, was almost completely sealed off from the outside world and no strangers were admitted. All that was known was that coffee beans came from Kaffa. It is therefore at least possible that Kaffa gave its name to coffee.

CHARACTERISTICS AND HABITAT

There are differences in the colour of the leaves, which are either yellowish-green or reddish-brown. There are also differences of leaf form; thick

fleshy leaves are found contrasting with small narrow ones. The shape and colour of the fruit show equal variation: from red to yellow, from spherical to elongated. In some the remains of the calyx stay attached to the berry throughout the period of growth and ripening, forming a small crown on the proximal end of the fruit, whereas normally in *Coffea arabica* only a simple ring (discus) is found in this position.

In the forests, whether primary or secondary, with a thick stand of trees of every age and height whose canopies interlace and greatly reduce the light, and with a strong shrubby undergrowth, the coffee tree has to face fierce competition.

The coffee trees prefer the more open places. The seedlings, which cover the ground often as thickly as in a nursery, are in the majority over adult plants. They are drawn up into a spindly growth. The ratio of stem diameter to height is very unfavourable, averaging 1:142·7. Primary branches are usually lacking up to a height of six to ten ft. The top of the tree consists of an unbranched leader which only attains a small diameter. In these circumstances fruit production can only be small. Picking under such conditions is expensive and difficult. Generally the crowns of the trees are pulled down with hooked poles from the ground, and often they cannot erect themselves again.

This kind of stand of coffee provides the starting-point for a primitive sort of cultivation by the inhabitants. The forest canopy is either severely thinned or entirely removed by felling. The undergrowth is also cleared. Now the coffee tree finds favourable conditions of growth. It develops strong stems, forming their first branches near the ground. The crowns grow out into a bush shape. Ten to twelve year old trees show a stem diameter of 8 in., corresponding to a ratio of 1:40. Very often several plants growing from one spot unite into a group which has the effect of a single bush. One also finds larger areas in which it is only possible to force a way with difficulty between trunks 10 to 13 ft high and as thick as an arm.

If such a stand receives no further attention in the form of annual cleaning and of clearing the edges against re-invasion by the forest, then in the course of time the forest re-asserts its supremacy. The first invaders are grasses, particularly the pernicious *Digitaria abyssinica*, which spreads increasingly among the coffee trees, especially where they are least dense. By degrees they supress the succession of young coffee trees completely. The older coffee trees begin to succumb; first sections of branches die back, and finally the whole plant. Lianas and undergrowth, invading from the edges, grow through and over the coffee trees. Climbers and creepers in the greatest variety form a thick carpet over the crowns of the coffee. Formation of branches and foliage declines. Here and there the tip of a coffee tree pierces the felted covering; but in a short time it too is enveloped. In the moist, darkened, airless space beneath the covering of lianas, lichens and mosses a yard in length develop, and numerous epiphytes establish themselves. The forest has regained its ancient territory.

The inhabitants had in general not gone further than the primitive efforts to exploit the coffee stands which have been described above. It was only after the second World War that various attempts on the part of the larger forest proprietors to do something more for their property became apparent.

The rise in coffee prices on the world market very probably played a role which is not to be under-estimated, and induced some inhabitants here and there to undertake regular cultivation, repeated annually. The irregularly distributed stands of coffee in the forest began to be cleared each year of their weed growth. The natural shade trees were not destroyed by clear felling, but only carefully thinned. No attention at all, such as thinning or pruning, was given to the coffee trees themselves.

It should be remarked here that the people have an almost holy horror of destroying any crop plant, wherever they may encounter it. Accordingly every coffee seedling was allowed to remain, even when a stand was too dense or the seedlings had to force themselves through too thick a canopy of senile trees. Thus the coffee still grew in weak spindly forms, as described above. However, action was taken to plant up the areas of forest, intervening between stands of self-sown coffee, with coffee bushes.

Planting takes place at the beginning of the rains. Two to three year old seedlings, averaging two feet high, are taken from the natural stands of coffee. The people take little trouble to lift them with the root system intact. The plants are simply torn out of the loose forest soil. At the planting site a hole is made with a stick as thick as the forearm, the seedling is thrust in and firmed with a stamp of the foot. No great trouble is taken with the finer rootlets which may have survived the rough uprooting; they are usually twisted like a ball round the taproot. Spacing is irregular and done by eye at about three feet square. Older coffee trees can already be observed, some six feet high and bearing fruit, which were planted in this primitive fashion. No pruning back of the branches is done. It is no wonder that only about 30 per cent of the transplants grow, and begin to bear fruit after about five years on average. It is however more surprising how many plants, which appear to be completely dead, send up young growth from the roots during the following rains.

In this method, no consideration is given to the actual depth of planting; most of the seedlings stand either too deep or too high, and this later leads to serious disturbance of growth when the trees begin to bear. No further removal of weed growth in the plantation takes place; the people are of the opinion that weeds climbing over the coffee support it in its growth.

The harvesting and preparation of the beans are equally carefree. At an advanced stage, when some of the berries are already overripe and have fallen to the ground, a single picking is made at which all cherry, whether overripe, ripe, or green, is stripped from the branches and the fallen berries are picked up. For drying, the cherry is spread out on a piece of ground which has been superficially cleaned. It is seldom that all grass growth is removed from it. The drying berries are not sheltered against rain or dew; they remain in the open until they are more or less dry, which under such circumstances may take weeks. Moulds develop, and the whole product takes on an earthy musty smell. In many places also the berries are thrown immediately after picking into pits in the ground, where they undergo a haphazard fermentation before being spread out to dry. The quality is thereby improved according to local opinion.

Before the berries are fully dry, they are either packed into sacks and taken to market, or passed through a wooden huller to remove the husks. Small

quantities are also hulled by hand with grinding-stones. In one part of the province, where the cultivators live along roads which carry much traffic, they spread out their berries on the road too and allow passing vehicles to do the hulling. The buyer obtains in general a product of high moisture content and is usually constrained to dry it further. However the producers are of opinion that they obtain more money by the sale of such a wet product than of dry berries, which naturally weigh less for the same volume.

The yield per hectare from wild coffee stands by the methods described does not exceed $1\frac{1}{2}$ cwt, and is often very much less. The final product does not satisfy in any way the requirements of quality for the international market. Nevertheless, oversea exports of coffee from Abyssinia, of which the largest part goes to the United States, have risen steadily and account by value for about 60 per cent of the export tax on all articles exported.

The few parcels of coffee, which are reasonably well prepared, show that the local coffee could take a place among the world's highest grades. This is due to the optimal conditions of soil and climate, which are evinced by the fact that the coffee grows and bears fruit in spite of such rough treatment.

The provincial government is now taking action, both through the issue of loans from the Development Bank which are conditional upon the use of prescribed methods in cultivation and drying, and through a 'Joint Fund' which works in cooperation with the 'Point Four Programme' to improve cultivation and preparation.

This work meets with enormous difficulties, because a tradition centuries old has to be altered. In practically every other coffee-growing country of the world, coffee plants were introduced by Europeans who also brought with them and developed the best methods of cultivation. If the indigenous population later took up coffee-growing themselves, they naturally adopted the techniques which they had seen and learned on European plantations. In Ethiopia on the other hand the inhabitants, who well know that their country is the home of coffee, must first be laboriously persuaded that the methods of coffee cultivation handed down by their forefathers are not the best and most profitable.

Ipomoea Reptans, *Poir. A Useful Tropical Fodder Plant?*

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This species (synonym: *Ipomoea aquatica*, Forsk.) is found growing in marshy or wet sandy places or floating on water in many parts of tropical Asia, Africa and Oceania. It was probably introduced into tropical Australia and some of the Pacific islands by Chinese immigrants[1]. In Malay it is known as *kangkong*, in Tamil as *vallai-keerai*, in Fijian as *ota karisi* or water cress. In other parts of South East Asia and Oceania it is known as water spinach or swamp cabbage.

BOTANICAL DESCRIPTION

It is a member of the family Convolvulaceae and is a glabrous perennial, with long, prostrate, trailing or floating and hollow stems, often rooting at the nodes and sometimes bearing short, ascending branches. The leaves are borne on long petioles, from ovate to linear-lanceolate, acuminate, always cordate or hastate at the base, the angles rounded or produced into broad or narrow acute auricles, usually two or four inches long, though when the plant is fertilized, much longer. Occasionally on the small branches are a few small ovate-cordate and obtuse leaves. Peduncles one- or few-flowered. Sepals rather obtuse, three to four lines long. Corolla tubular at the base, pink-purplish or white, about one and one half inches long. Filaments hairy at the base. Ovary two celled. Capsule globular, coriaceous, apparently indehiscent or bursting irregularly. Seeds large, woolly, often reduced to two[2]. *Figure 1* shows a healthy *Ipomoea reptans*.

CHEMICAL COMPOSITION

On a chemical basis it will be seen from *Table 1* that *Ipomoea reptans* is an excellent feed, high in protein and ash and low in crude fibre. It has a narrow nutritive ratio of 1 : 2·1 and a high calculated digestibility according to G. L. Teik[4]. It is a fair source of calcium and phosphorus and a good source of iron, rich in carotene and quite a good source of several vitamins. The mineral and vitamin contents[5] per 100 gm of *Ipomoea reptans* (probably leaf or leaf and stem only) are calcium 59 mg, phosphorus 41 mg, iron 2·0 mg, Vitamin A 5100 i.u., thiamine 0·07 mg, riboflavine 0·12 mg, nicotinic acid 0·70 mg and ascorbic acid 32 mg.

PRESENT USE

The value of *Ipomoea reptans* as a vegetable for human consumption is well recognized throughout the tropics, particularly in South East Asia. Usually only the terminal shoots or the young leaves are used and they are cooked in a variety of ways.

The value of it as a fodder for the feeding of livestock is almost unrecognized, and there are no known references to its use. A. CHEVALIER[6] mentions that several different species of *Ipomoea* are fed to sheep and dairy cattle in tropical Africa but that *Ipomoea reptans* is poisonous. It is very unlikely that this is true as the plant is used so widely as a vegetable for human consumption. It is known to be grown on fish ponds in Malaya and fed to pigs[7], but it is not known how widespread is this practice and if it is carried out in other countries.

Figure 1.

In Fiji attention was first focused on this plant in 1954 when it was grown on the surface of a small fish pond stocked with the fish *Tilapia mossambica.* It was found that the yield of the plant was very high, that it was easy to harvest; chemical analysis showed it to be a fodder plant of exceptional nutritional value, very palatable to pigs and to cattle. Little information is yet available about yield, but in the first twelve months of growth on a small fish pond fed by effluent from a piggery it produced green feed at the rate of 90 tons per acre per annum, the major part of the growth taking place in the summer time. The environment in this experimental pond was undoubtedly very favourable to quick and vigorous growth.

It was found that the most suitable method of harvesting *Ipomoea* was to harvest the whole plant. If it is allowed to cover a pond completely, strips one or two yards wide can then be cut through the dense mass of foliage lying on the surface. At Sigatoka a cane knife is used for this work (*Figure 2*). The foliage can then be rolled up like a carpet and dragged out of the pond.

Figure 2.

Figure 3.

Table 1.

Chemical analysis of Ipomoea reptans (*dry matter basis*)

	Dry matter %	*Crude protein* %	*Crude fibre* %	*Crude fat* %	*Total ash* %	*N-Free extractive* %
Fiji[3]						
Leaves and shoots	9·2	34·3	10·2	3·9	12·9	38·7
Whole plant	6·9*	19·6	20·4	3·4	15·5	41·1
Malaya[4]						
Leaves and stems	7·5	28·0	12·0	2·7	18·7	38·6

*The percentage dry matter content of the whole plant is lower than that of the shoots because the stalk is hollow and full of water.

Regrowth begins immediately from both sides of the cut until the gap is filled again with foliage. The procedure can then be repeated. It is not known how well this procedure would work on a large scale but it certainly works well in small ponds.

With regard to the nutritional value of *Ipomoea reptans* only chemical information is as yet available, as no digestibility trials have been made, but pigs and cattle eat the plant greedily and it is obviously very palatable (*Figure 3*). Pigs relish it more than they do any other green feed fed to them at Sigatoka. It has now been fed for a period of more than a year to pigs and dairy calves with no ill results, though the animals eat it so greedily that they tend to ' scour ' and it is now fed mixed with elephant grass (*Pennisetum purpureum*) with which it makes an excellent combination.

Ipomoea reptans is by any standards an exceptionally valuable fodder plant, useful for growing in swamps or on open ponds. It is not known whether it would stand up to grazing in swampy areas, but this is unlikely. It is probable that it will thrive best on open ponds into which effluent flows and that it will have to be harvested by cutting. It is hoped that it will be possible to study thoroughly its possibilities as a fodder plant at this station in the future.

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REFERENCES

[1] Hillebrand, W. (1888). *Flora of the Hawaiian Islands. New York, London*
[2] Bailey, F. M. (1900). *The Queensland Flora Part III*, Queensland Government: Brisbane
[3] Payne, W. J. A., Naidu, R. K., Sills, V. E. and Holmes, S. V. (1954). Fish Farming *Agric. J. Fiji*, **25,** (3, 4), 71
[4] Teik, G. L. (1951). Fodder and Feeding Stuffs in Malaya *Dept. Agric. Fed. Malaya, Sci. Series*, **24,** 68
[5] Wu Leung, Woot Tsuen, Pecot, R. K. and Watt, B. K. (1952). *Composition of Food used in Far Eastern Countries.* Bureau of Human Nutrition and Home Economics. U.S. Dept. Agric., Agric. Handbook No. 34
[6] Chevalier, A. (1950). Some Fodder Species of *Ipomoea* and the Poisonous Convolvulaceae of the Sahel Zone in West and Central Africa. *Rev. Bot. appl.*, **30,** 372
[7] Le Mare, D. W. (1953). Private communication

The Germination of Cane Cuttings, with Special Reference to Damage Caused by Hot Water Treatment

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The stimulating effect of the 'short' hot water treatment (20 min. at 52° C) on the germination of cane cuttings has long been recognized; a small stimulation is noted in some of the experiments reported here. However, the 'long' hot water treatment (2 hr at 50° C), as used for the control of ratoon stunting disease, creates a serious problem in that greatly reduced germination can occur after treatment.

In 1953, ratoon stunting disease was reported in the Caribbean area, and suitable treatment tanks were developed by Bookers' Sugar Estates in British Guiana. One of these tanks was employed for the treatment of the cuttings used in the experiments described in this paper. This tank is of a fairly large capacity (holding up to two tons of cane in four compartments), and has a very rapid water circulation which allows the temperature to be maintained at 50° C $\pm \frac{1}{2}$° C for any period of time. Experiments were initiated to determine the extent of, and evaluate the yield reduction caused by, ratoon stunting disease (making use of hot water treatment). It immediately became apparent that, whilst some planting material gives satisfactory germination after treatment, other material gives extremely poor germination. For commercial application, it is essential to use only cane that will germinate well. A number of simple trials, *I* to *III*, were laid down to determine whether the stage of maturity of the cane affects the resistance to damage caused by the treatment. These experiments gave conflicting results, except that susceptibility to treatment seemed to be associated with the basic quality of the planting material.

A considerable amount of work has been reported concerning the factors which influence germination. Thus, G. Arceneaux[1] and H. Evans[2] have indicated the importance of a high nutrient status. The effect of various diseases in reducing germination is well known: for example, P. B. Hutchinson and W. S. Wise[3] have reported on the effect of chlorotic streak disease. Other work has been reported on the levels of carbohydrates and auxins in the stem. Of external characteristics there have been numerous reports of the value of a long internode attached to the bud; but most of this work refers to single eye cuttings. Thus good planting material can be described as that which is healthy and of high nutrient status, and probably with long internodes. Further, as H. F. Clements[4] has shown, the eyes should be young, though not the very immature eyes at the top of the stem. As this description, in respect of superficial characteristics, seemed inadequate, investigations were continued to determine more precisely the effect of

various external characteristics on the germination of both untreated and hot water treated cane. The results are reported in experiments *IV* to *VI*.

EXPERIMENTAL METHODS

In all experiments now reported, three eye ' seed ' pieces were used. The cuttings were germinated in the following way: they were placed on a base of 4 to 6 in. of bagasse, and covered with a further 2 in. layer of bagasse; all eyes were placed horizontally, and all faced in the same direction ; watering was carried out as necessary to keep the bagasse moist, excess water draining away readily. The time allowed for germination was three to four weeks, dependent on external temperature; this period was kept short because, under field conditions, cuttings which have not germinated in that period will have little chance of normal establishment. Experimental designs were the usual factorial designs; each plot consisted of ten three eye cuttings (*i.e.* thirty eyes). Except for *I* all experiments had two replicates. It should be noted that this plot size (or number of replicates) is too small to allow for analysis of variance, as the variation within a treatment is large.

Three methods of selection of cuttings were used:

(*a*) *I* to *III*; a suitable number of canes were collected and were cut, throughout their length, into three eye cuttings. Those with very hard or very soft eyes, and those which were damaged, were rejected. The sound pieces were allocated at random to the treatments.

(*b*) *IV* and *V*; the canes were selected in the field by a random method. They were then cut in half, and only one three eye cutting, the central piece of each half, taken to represent ' tops ' and ' bottoms '. These cuttings were then allocated at random to the treatments.

(*c*) *VI*; the field selection was by a random method. Each cane was cut into three eye pieces; these pieces were then sorted to conform with arbitrary ' type of eye ' groups.

In all experiments, the number of eyes germinating and the number of eyes emerged (that, is, showing at least one green leaf) were counted. In *IV* to *VI*, these counts, together with the total length of shoot, were made individually for each cutting. In these same experiments each cutting was measured individually for length, diameter and volume before germination. The length was measured from the 1st to 3rd node; the diameter was taken as the average of two measurements taken at 90° on the two internodes.

RESULTS

Experiment I—A 3 × 3 × 3 factorial; the following symbols are used:

Variety; V_1, B.4098. V_2, B.37161. V_3, B.41227.

Age; A_1, 4 month cane, A_2, 8 month cane, A_3, 12 month cane.

Treatment; T_0, untreated. T_1, $\frac{1}{2}$ hr at 50° C, T_2 2 hr at 50° C. The germination count (the age-treatment interaction table) at three weeks is given in *Table 1*. This experiment had one replicate, giving 90 eyes per A/T group. Only the eight-month cane showed any resistance to the long hot water

treatment. The different varieties showed similar damage by treatment. B.41227 Had a normal response to treatment, but had a lower germination throughout (variety table not included).

Table 1. Number of eyes germinated

Group	T_0	T_1	T_2	*Total*
A_1	64	64	4	132
A_2	48	54	30	132
A_3	47	35	12	94
Total	159	153	46	358

Experiment II—Varieties and treatments: as experiment *I*. The germination count (the age–treatment interaction table) is shown in *Table 2*. This experiment had two replicates, giving 180 eyes per A/T group. In this case, germination was generally better than in *I*. Neither age nor hot water treatment had any marked effect on germination.

Table 2. Number of eyes germinated

Group	T_0	T_1	T_2	*Total*
A_1	140	149	142	431
A_2	133	134	152	419
A_3	131	136	126	393
Total	404	419	420	1243

Experiment III—A $3 \times 3 \times 2$ factorial; the following symbols were used:

Variety; V_1, B.4098. V_2, B.37161. V_3, B.41227.

Treatment; T_1, untreated. T_2, $\frac{1}{2}$ hr at 50° C. T_3, 2 hr at 50° C.

Part of Cane; P_1, tops. P_2, bottoms. All cane in this experiment was 12 months old. The germination count at four weeks is given in *Table 3*. There are 60 eyes per plot. B.37161 Gave much better germination, in the untreated series, than the other varieties; and its germination was little impaired by the long treatment. Of the other varieties, about ten eyes had been killed whatever the initial germination.

Table 3. Number of eyes germinated

Group	T_0		T_1		T_2		*Total*
	P_1	P_2	P_1	P_2	P_1	P_2	
V_1	44	34	54	44	36	25	237
V_2	58	44	43	52	52	42	291
V_3	47	27	49	29	34	19	205
Total	254		271		208		733

Experiment IV—This trial used B.37161 from fields due for harvest (*i.e.* 12 months old): A_1, site No. 1, A_2, site No. 2, B_1, mature cane, B_2, ' water ' shoots, C_1, bottoms, C_2, tops, D_1, untreated, D_2, 2 hr at 50° C. (Site No. 1 was more fertile than site No. 2; ' mature cane ' had 24 to 30 joints; ' water shoots ' had 12 to 15 joints.)

The germination (that is, eyes which were showing at least one green leaf) at three weeks is given in *Table 4.*

Table 4. Number of shoots emerged

Group	D_1				D_2			
	C_1		C_2		C_1		C_2	
	B_1	B_2	B_1	B_2	B_1	B_2	B_1	B_2
A_1	0	7	27	36	2	19	19	23
A_2	0	0	13	36	3	1	12	0

The large plot differences within this table, *e.g.* C_1D_1 *v.* C_2D_1 cannot be attributed to any difference in the size of cuttings. However, regressions were calculated for the following: diameter of cutting: total length of shoot; length of cutting: total length of shoot; volume of cutting: total length of shoot. Using all the data, there appeared to be a slight correlation between diameter of cutting and total length of shoot. As most groups contained large numbers of cuttings which did not germinate, regression analysis was carried out on the homogeneous group $(A_1 + A_2)$ $(B_1 + B_2)$ C_2D_1 which gave good germination. No correlation was obtainable of total length of shoot with length of cutting, but the following regression on diameter of cutting was obtained:

$$y = 30{\cdot}31x - 60{\cdot}61$$

with $r_{78} = 0{\cdot}402$ (significant at $P > 0{\cdot}001$)

where y is total length (cm) of shoot per cutting and x is average diameter (cm) of cutting

Experiment V—This experiment used B.41227 of different ages: A_1, sites 1 and 3, A_2, sites 2 and 4, B_1, 8 month cane, B_2, 4 month cane, C_1, bottoms, C_2, tops, D_1, untreated, D_2, 2 hr at 50° C. The germination at three weeks is given in *Table 5.* As in *IV*, the major plot differences between B_1 and B_2

Table 5. Number of eyes emerged

Group	D_1				D_2			
	C_1		C_2		C_1		C_2	
	B_1	B_2	B_1	B_2	B_1	B_2	B_1	B_2
A_1	13	44	30	28	10	44	5	29
A_2	0	45	31	36	5	28	7	24

cannot be attributed to differences in the size of the cuttings. All the B_1 plots, except $B_1C_2D_1$, germinated so badly as to make impossible any regression analysis. But the B_2 plots form a homogeneous group with good germination, and gave the following regressions of total length of shoot on

diameter of cutting: where y is total length (cm) of shoot, and x is diameter (cm) of cutting for B_2 D_1 plots:

$$y = 59{\cdot}97x - 92{\cdot}00$$

with $r_{78} = 0{\cdot}432 \qquad (P > 0{\cdot}001)$

for B_2 D_2 plots:

$$y = 55{\cdot}37x - 81{\cdot}94$$

with $r_{78} = 0{\cdot}279 \qquad (P > 0{\cdot}01)$

A trend of improving germination with increasing diameter is also apparent in the B_1 plots, but no significant correlation could be obtained. There is also some correlation with length of cutting in the B_2 series: where y is total length (cm) of shoot, and x is length (cm) of cutting

$$y = 34{\cdot}9 + 1{\cdot}5x$$

with $r_{158} = 0{\cdot}195 \qquad (P > 0{\cdot}05)$

Experiment VI—B.37161 Was used throughout. Cane was collected at two different ages, *viz.* 4½ and 8 months; in each group, the cane was collected from each of three separate sites. Each lot of cane was cut into three eye pieces, and those pieces that fell into the undermentioned arbitrary groups of type of eye were sorted. No further treatment was applied, the cuttings being germinated in a randomized block layout, using two replicates: A_1, A_2, A_3, eight month cane from three sites; A_4, A_5, A_6, four month cane from three sites; B_1, hard eyes but scales splitting; B_2, medium hard eyes, fully swollen and coloured, but with no splitting of bud scales; B_3, young eyes, swollen and pigmented; B_4, young eyes, still flat, mainly green.

Table 6. Total length of shoot (cm)

Group	B_1	B_2	B_3	B_4	*Total*
A_1	268	804		681	1753
A_2	11	38		507	556
A_3	147	248		318	713
A_4			942	971	1913
A_5			966	1097	2063
A_6			1258	994	2252
Total	426	1090	3166	4568	9250

Table 7. Average diameter (cm)

Group	B_1	B_2	B_3	B_4	*Average*
A_1	5·9	5·5		5·8	5·73
A_2	5·4	4·8		4·9	5·03
A_3	6·0	5·3		4·9	5·40
A_4			5·4	5·7	5·55
A_5			6·2	5·3	5·75
A_6			6·0	5·8	5·90
Average	5·77	5·20	5·87	5·40	5·55

The results of the four-week measurement of total length of shoot are given in *Table 6*, and the average diameter of the cuttings in *Table 7*. It is apparent, from these tables, that the diameter of the cutting has a marked effect on the germination potential within the four month and eight month groups separately; but the age of the cane, *i.e.* four month as against eight month, has a much greater effect. Also that, within the eight month age group, the type of eye has an overwhelming effect on the germination potential.

Regressions were obtained for all groups separately: where y is total length of shoot and x is diameter of cutting :

for $(A_1 + A_2 + A_3)B_1$	y	=	$12{\cdot}45x$	—	$29{\cdot}10$
with	r_{58}	=	$0{\cdot}26$		$(P > 0{\cdot}05)$
for $(A_1 + A_2 + A_3)B_2$	y	=	$28{\cdot}45x$	—	$49{\cdot}30$
with	r_{58}	=	$0{\cdot}44$		$(P > 0{\cdot}001)$
for $(A_4 + A_5 + A_6)B_3$	y	=	$34{\cdot}45x$	—	$45{\cdot}15$
with	r_{58}	=	$0{\cdot}33$		$(P > 0{\cdot}01)$
for $(A_1 + A_2 + A_3)B_4$	y	=	$23{\cdot}50x$	—	$40{\cdot}25$
with	r_{58}	=	$0{\cdot}35$		$(P > 0{\cdot}01)$
for $(A_4 + A_5 + A_6)B_4$	y	=	$18{\cdot}50x$	+	$0{\cdot}40$
with	r_{58}	=	$0{\cdot}20$		(P—not significant)

With two exceptions, these regressions show that the various groups have a very similar germination potential. The old eyes (B_1) have a low germination rate which does not respond in the same way as the others to increasing diameter. The very young eyes on the young cane, on the other hand, are very vigorous, even the thin canes germinating almost as well as the thick canes. No overall relation could be detected between germination and length of cutting.

The multiple regression of length of shoot on diameter and length of cutting was:

$$y = 233{\cdot}37x_1 - 0{\cdot}36x_2 - 545{\cdot}52$$

where y is total length (cm) of shoot, x_1 is diameter (cm) of cutting and x_2 is length (cm) of cutting. The x_1 fraction is highly significant, and the x_2 fraction is not significant.

DISCUSSION

When precautionary measures were first taken, in British Guiana, against ratoon stunting disease, it was assumed that ' hard ' cane would withstand the long hot water treatment (2 hr at 50° C) with less damage than ' soft ' cane. Experiment *I* seemed to confirm this: the fairly hard eight month cane gave a markedly superior germination to the young four month cane. The twelve month cane, on the other hand, appeared to be too mature to germinate well after any treatment. This result, however, could well have been a fortuitous response to different nutrient levels for example, as the different varieties and ages were collected from different sites. To check this, the experiment was repeated (*II*), using the same varieties and ages, but collecting the cane from different sites. These results, contrary to those of *I*, did not indicate any age effect on the susceptibility of cane to treatment.

In *III* fertility differences were avoided by comparing the ' tops ' and ' bottoms ' of mature cane. A lower germination of the mature cane was evident, but there was no indication of differential susceptibility to treatment due to hardness of the material. However, one further point emerged from *III*: that approximately the same number of eyes are killed by hot water treatment whatever the initial germination. The result with B.37161 in this

experiment also suggests that, where the initial germination potential is very high, little or no damage may be done by treatment. This could explain the different results obtained in *I* and *II*.

The tentative conclusion may be drawn from these initial experiments that the same factors influence germination potential of cane regardless of treatment. This conclusion is upheld by the results of *IV* and *V*. If the successful application of long hot water treatment depends on the initial quality of the planting material, it is necessary to be able to define what is meant by good planting material This issue has not previously been acute because anything other than very poor material will give reasonable results under conditions of normal field practice. For convenience in the field this definition should, if possible, be made on external characteristics.

It is known that a high nutrient status in the cane is essential for good germination. This condition is likely to be associated with large internodes. The length of the cutting has been shown to be of importance in the germination of single-eye cuttings[5]. K. Chant, P. B. Hutchinson and W. S. Wise[6] found a correlation between germination and diameter of cutting. Their work on heat transmission through cuttings also suggests that diameter may be of importance in resistance to damage by treatment. Experiments were continued to determine whether the quality of planting material could be defined sufficiently (for practical purposes) in terms of external characteristics. This was done for both treated and untreated canes. Experiments *IV* and *V* were designed for this purpose. Each cutting was measured separately for length and diameter, and the germination measured individually. Good correlations were obtained between diameter of cutting and germination ; correlation with length of cutting was poor.

The regression of germination on diameter of untreated cane was very similar to that of treated cane (*cf.* the regressions for $B_2\ D_1$ and $B_2\ D_2$ in *V*). In other words, diameter changes affect the germination potential of treated and untreated canes equally. Further, an increase in diameter does not increase the resistance of the cutting to damage by hot water treatment. This is not at variance with the results of Chant, Hutchinson and Wise[6], as any damage to germination will occur in the meristematic tissue at the buds, that is, on the outer surface of the cane.

Although a highly significant regression can be obtained of germination on diameter, the correlation coefficient shows that only a small proportion of the variation in germination is explained by diameter. Also, diameter differences do not account for the differing germination potentials of different groups of canes (*e.g.* C_1D_1 *v.* C_2D_1 in *IV*). The best correlation coefficients were obtained from those groups where the type of eye was most likely to be constant: in *IV*, the C_2 eyes were all young, from the cane tops; in *V*, the B_2 canes, at four months, had only seven to twelve joints, so that all the eyes were young. A significant regression could not be obtained from the other groups, as the variance was too great: these groups contained eyes at all stages of maturity.

Experiment *VI* was designed to test whether most of the variation in germination could be explained in terms of joint size and condition of eye. The cuttings were sorted into arbitrarily chosen groups of types of eye, and

regressions on size calculated within these groups. The results of this experiment again show a good correlation of germination with diameter of cutting, but no correlation with length of cutting. Further, it is evident that, as the eye matures, it has a much reduced germination potential; also the age of the cane, independently, affects germination potential. Thus, on a cane of any given diameter, a young eye will germinate better than a mature eye; further, a young eye on a young cane will germinate better than a similar eye on an old cane.

The best correlation coefficient obtained, even within one eye type/age group, is only 0·44. Again, the differences in germination between sites in any one age/type of eye group *VI* are not fully explained by the regression on diameter calculated for that group. For example, in the eight month cane, the respective regressions underestimate the site differences in the B_2 group, and overestimate those differences in the B_4 group.

Thus variation in germination is not fully explained in terms of these external characteristics. Such a direct correlation cannot, however, be expected, as the variables are controlled by complex physiological mechanisms; the mechanism controlling morphology will not be exactly the same as that controlling germination.

However, the correlation is sufficiently good to make these factors (diameter, age and type of eye) useful in the choice of planting material.

The results of these experiments show that the best germination (from hot water treated or untreated canes) will be obtained from very young eyes from young cane. In practice, such young eyes could not be used for two reasons: firstly, the soft tissue is too easily attacked by pests and diseases, and is readily subject to mechanical damage; secondly, it would not be possible to remove the leaf sheaths, on a commercial scale, and the leaf sheaths would interfere with germination (see Clements[4]).

CONCLUSIONS

The successful establishment of a plant cane crop depends on the use of cane sets of good quality. The selection of material with high germination potential becomes much more important when ' long ' hot water treatment is used, as this treatment normally kills a proportion of the eyes. The quality of planting material is largely associated with easily recognized external characteristics, namely the diameter of the cane and condition of the eye, as well as freedom from disease and insect or mechanical damage. These factors influence germination whether the cane receives hot water treatment or not.

Cane with the following characteristics should be chosen for planting: the chosen stand should be one with canes of uniformly large diameter; the canes should be as young as possible, so that the basal eyes have not become hard and mature; mature eyes that are beginning to swell, that is, with the outer bud scales splitting, germinate badly as a cane set.

SUMMARY

1. Experiments were directed towards determining the type of planting material that could best withstand the hot water treatment for ratoon stunting disease.

2. Experimental methods are described, and results given.

3. It was found that certain external characteristics—diameter of cane and type of eye—largely control the quality of planting material, whether subjected to hot water treatment or not.

4. The external characteristics do not explain all the variation in germination, but correlations are sufficiently good to use them in the selection of planting material.

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REFERENCES

[1] Arcenaux, G. (1948). *Sug. Bull. (La.)* **26,** 389, 404
[2] Evans, H. (1938–39). *8th and 9th Ann. Rep. Sug. Res. Sta., Mauritius*
[3] Hutchinson, P. B. and Wise, W. S. B.W.I. Soc. Sug. Tech. Congress 1954
[4] Clements, H. F. (1940). *Haw. Pl. Rec.* **44,** 117
[5] Report. (1949). Expt. Sta. Haw. Sug. Pl. Assoc.
[6] Chant, K., Hutchinson, P. B., and Wise, W. S., *Tech. Rep. B.W.I. Sug. Res. Team* No. 54/1.

The Application of Foliar Analysis to Oil Palm Cultivation

III. Foliar Analysis and Mineral Deficiencies

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Recent investigations on oil palms have shown that the chemical composition of leaves in the same morphological position fluctuates within narrow limits, provided nutritional and environmental conditions are normal[1–6]. Before applying the method of foliar analysis in the diagnosis of mineral deficiencies in oil palm plantations, the chemical composition characteristic for each particular deficiency should be determined. Although the foliar analysis of fertilizer experiments may constitute a useful aid in this respect, soil conditions are never sufficiently stable to exclude interactions between unknown nutritional conditions and the treatment from the experiment.

Sand culture experiments, in which nutritional conditions may be closely controlled, are useful for determining changes in leaf composition of palms which are deficient in one of the major nutrients. A comparison of the changes in leaf composition of palms receiving a complete nutrient solution and those which are deficient in one particular major nutrient was undertaken.

METHOD

In January 1954, oil palm seedlings, approximately nine months old, were planted in halves of 200-litre drums, containing washed river sand. Soil adhering to roots was removed with tap water before planting. Chemical analysis of the sand revealed that potassium, calcium and magnesium were absent, but that some phosphate was present. The design of the experiment was a 6 × 6 Latin square, including the following treatments: palms watered daily with a complete nutrient solution; palms watered daily with a complete nutrient solution minus nitrogen; palms watered daily with a complete nutrient solution minus phosphorus; palms watered daily with a complete nutrient solution minus potassium; palms watered daily with a complete nutrient solution minus calcium; palms watered daily with a complete nutrient solution minus magnesium. The nutrient solution used was that recommended by E. J. Hewitt[7]. When a cation was omitted it was replaced by a sodium ion, when an anion was omitted it was replaced by a sulphate ion. Each palm received 1·5 to 2 litres of solution daily, adjusted to *p*H 5·0. Holes in the base of the drums allowed free drainage. In each palm, leaflets were taken from the central part of the youngest fully opened leaf at monthly intervals and analysed for potassium, phosphorus, calcium, magnesium and ash contents.

RESULTS

The average chemical composition of the monthly samples from each treatment during a 16 months period is given in *Table 1.* A limited number

Table 1. Leaf composition of ' normal ' and mineral-deficient oil palms*

Treatment	Element in leaf percentage	1954								1955			
		Feb.	*March*	*April*	*May*	*June*	*July*	*Aug.*	*Dec.*	*Jan.*	*Feb.*	*March*	*April*
Complete	K	1·90	1·86	2·01	1·91	2·71	2·34	2·62	3·05	2·35	2·17	2·14	2·95
	P	0·284	0·291	0·323	0·317	0·338	0·314	0·364	0·230	0·213	0·260	0·257	0·267
	Ca	0·625	0·618	0·615	0·657	0·652	0·669	0·595	0·684	0·717	0·535	0·472	0·566
	Mg	0·290	0·240	0·261	0·234	0·230	0·356	0·376	0·234	0·248	0·318	0·335	0·305
	Ash	7·09	6·68	7·56	5·84	6·96	7·52	8·22	9·42	8·29	7·00	7·48	8·87
Minus nitrogen	K	1·99	1·70	2·18	2·19	2·36	2·35	2·66	2·98	2·26	2·62	2·97	2·87
	P	0·266	0·425	0·638	0·665	0·622	0·715	0·448	0·273	0·239	0·276	0·225	0·299
	Ca	0·628	0·738	0·800	0·766	1·380	0·970	0·770	0·867	0·795	0·816	0·746	0·763
	Mg	0·291	0·348	0·452	0·542	0·424	0·426	0·318	0·425	0·304	0·373	0·398	0·378
	Ash	6·57	7·42	9·28	8·73	10·08	9·70	10·17	11·72	9·89	10·87	11·39	11·53
Minus phosphorus	K	2·23	1·83	2·02	1·96	2·86	2·15	2·48	3·01	2·05	2·31	2·14	2·62
	P	0·241	0·233	0·245	0·264	0·263	0·197	0·287	0·194	0·210	0·196	0·244	0·250
	Ca	0·689	0·693	0·637	0·582	0·560	0·596	0·560	0·679	0·602	0·531	0·504	0·454
	Mg	0·270	0·272	0·236	0·297	0·205	0·321	0·300	0·307	0·225	0·323	0·280	0·237
	Ash	6·91	6·53	7·68	6·56	6·27	6·64	7·75	9·19	7·69	6·94	7·69	7·32
Minus potassium	K	1·78	1·32	1·33	1·43	1·57	1·01	1·81	0·81	<0·70	<0·70	<0·70	<0·70
	P	0·256	0·292	0·334	0·327	0·354	0·405	0·480	0·288	0·269	0·271	0·244	0·270
	Ca	0·732	0·772	0·786	0·703	0·722	0·736	0·795	0·543	0·644	0·505	0·497	0·494
	Mg	0·301	0·341	0·352	0·324	0·368	0·396	0·351	0·364	0·331	0·351	0·363	0·428
	Ash	6·54	6·22	6·97	5·91	5·57	5·62	7·61	4·51	5·06	4·16	4·74	4·46
Minus calcium	K	2·20	1·85	2·17	2·31	2·95	2·02	2·57	2·66	2·34	2·36	2·60	2·62
	P	0·235	0·311	0·323	0·283	0·252	0·269	0·321	0·201	0·223	0·215	0·235	0·250
	Ca	0·606	0·576	0·523	0·436	0·390	0·333	0·347	0·303	0·404	0·404	0·339	<0·200
	Mg	0·289	0·313	0·291	0·297	0·268	0·300	0·278	0·282	0·330	0·348	0·351	0·316
	Ash	7·29	7·82	7·84	7·00	7·09	7·12	7·70	8·12	8·20	6·91	7·69	7·65
Minus magnesium	K	2·07	1·99	2·34	2·06	3·05	2·30	2·81	2·58	2·57	2·47	3·06	2·87
	P	0·234	0·301	0·329	0·310	0·328	0·364	0·402	0·232	0·260	0·271	0·235	0·270
	Ca	0·701	0·721	0·750	0·738	0·787	0·846	0·852	0·836	0·901	0·674	0·790	0·707
	Mg	0·256	0·227	0·224	0·275	0·196	0·320	0·250	0·196	0·255	0·270	0·204	0·197
	Ash	6·97	7·72	8·50	7·15	7·94	8·15	9·33	8·48	9·02	7·92	9·40	8·69

* Figures expressed as a percentage of dry matter—averages per month.

of samples were also analysed for their nitrogen content (*Table 2*). The analysis of variance of the data revealed both highly significant treatment and

Table 2. Nitrogen content of ' normal ' and mineral-deficient oil palms*

Treatment	1954		1955			
	June	*August*	*January*	*February*	*March*	*April*
Complete	3·30	2·47	2·53	3·57	2·24	2·02
Minus N	2·25	1·53	1·47	1·50	1·34	1·46
Minus P	3·06	2·99	2·48	3·15	2·54	1·69
Minus K	2·32	2·79	3·12	3·28	2·40	2·42
Minus Ca	2·92	2·65	2·72	3·06	1·99	1·84
Minus Mg	3·89	2·37	2·83	3·53	2·44	2·50

* Expressed as a percentage of dry matter.

month-of-sampling effects and months × treatment interactions. These are tabulated in *Tables 3* and *4*. From the experiments it was found that:

(*i*) *Nitrogen deficiency* is accompanied by a decrease of the nitrogen content and an increase of the phosphorus, calcium, magnesium and ash contents. Later, the phosphorus and magnesium contents decrease to a level slightly above normal. The potassium content, expressed as a percentage of ash, decreases.

Table 3. Average chemical composition of ' normal ' and mineral-deficient oil palms

Treatment	K%	P%	Ca%	Mg%	*Ash*%
Complete	2·33	0·288	0·617	0·286	7·58
Minus N	2·43	0·424††	0·837††	0·390††	9·78††
Minus P	2·29	0·235	0·591	0·273	7·27
Minus K	< 1·15††	0·318	0·661	0·356††	5·61††
Minus Ca	2·39	0·260	0·405††	0·305	7·54
Minus Mg	2·51	0·295	0·775††	0·239††	8·27
† *significant difference* P = 0·05	0·24	0·066	0·096	0·039	0·84
†† *significant difference* P = 0·01	0·32	0·090	0·131	0·045	1·14

Expressed as a percentage of dry matter.

(*ii*) *Phosphorus deficiency* causes a decrease in phorphorus content but there is an increase to a level slightly below normal, later. The calcium content decreases and remains low and the same trend was observed for the magnesium and ash contents.

(*iii*) *Potassium deficiency* may be recognized by the decrease in potassium and ash content. In the first stage of the deficiency, the phosphorus, calcium and magnesium contents increase but later the phosphorus and calcium contents (expressed as dry matter) decrease again, whereas the magnesium content remains high.

(*iv*) *Calcium deficiency* is characterized by a decrease in calcium and phosphorus contents. Later, the potassium and ash contents decrease slightly below normal.

(*v*) *Magnesium deficiency* results in a decrease in the magnesium content and an increase in calcium and ash contents.

Table 4. Differences in leaf composition between ' normal ' and mineral-deficient oil palms*

Treatment	*Element in leaf percentage*	1954								1955			
		Feb.	*March*	*April*	*May*	*June*	*July*	*Aug.*	*Dec.*	*Jan.*	*Feb.*	*March*	*April*
Minus nitrogen	K	9	−16	16	28	−35	2	4	−6	−9	45	83	−8
	P	−19	134	315	348	284	401	43	68	26	16	−32	32
	Ca	3	120	186	110	725	302	176	183	78	281	274	197
	Mg	1	108	191	208	194	70	−58	191	56	55	63	73
	Ash	−52	74	174	288	311	218	195	330	160	387	391	266
Minus phosphorus	K	33	−3	1	4	−2	−19	−15	−4	−30	14	0	−33
	P	−43	−58	−78	−53	−75	−117	−77	−36	−3	−64	−13	−17
	Ca	64	75	23	−79	−92	−72	−35	−5	−115	−4	32	−112
	Mg	−20	31	−26	45	−25	−34	−74	73	−23	5	−55	−68
	Ash	18	−16	12	72	−69	−88	−47	−23	−60	−6	21	−55
Minus potassium	K	−12	−54	−70	−48	−113	−133	−81	−224	<−200	<−200	<−200	<−200
	P	−30	1	1	10	16	96	116	58	65	11	−13	3
	Ca	107	154	171	47	69	67	200	−141	−73	−30	25	−72
	Mg	11	101	91	90	139	40	−25	130	83	33	28	123
	Ash	−55	−46	−59	7	−139	−190	−61	−491	−323	−284	−274	−441
Minus calcium	K	30	−1	16	39	24	−32	−5	−39	−1	19	46	−33
	P	−50	20	1	−46	−86	−16	−43	−29	10	−45	−32	−17
	Ca	−19	−42	−92	−220	−263	−336	−251	−381	−313	−131	−133	−366
	Mg	−1	73	30	40	38	−55	−97	48	82	30	16	11
	Ash	20	114	29	116	12	−40	−52	−130	−9	−9	21	−122
Minus magnesium	K	17	13	33	15	34	−4	20	−47	22	30	92	−8
	P	−50	10	7	−6	−10	50	38	2	47	11	−22	3
	Ca	76	103	136	81	135	177	257	152	184	139	318	139
	Mg	−18	−13	−37	41	−34	−36	−126	−38	7	−48	−131	−108
	Ash	−12	92	94	130	98	63	111	−94	73	92	192	−18

* Expressed as dry matter. Significant interactions at P = 0·05: K 62; P 133; Ca 255; Mg 112; Ash 227. For potassium and ash content the numbers have been multiplied by 100, for phosphorus, calcium and magnesium by 1000.

DISCUSSION

When the technique of foliar analysis is used to diagnose mineral deficiencies in plantations, it is of the greatest importance that the results are correctly interpreted. Many investigators, particularly those referred to by D. W. Goodall and F. G. Gregory [8], base their diagnosis on the percentage of the several elements found in the leaves The principle underlying this method of interpretation[9] is based on the assumption that plants will respond to applications of fertilizers when the concentration of nutrients in their tissues falls below a certain 'critical' level. The lower the nutrient concentration in the plant, the higher will be the growth response to the applications of the nutrient in question. When the critical levels for the various elements are known for a standard sampling and analytical procedure, recommendations of a practical nature become possible. If this principle is applied to the results of the sand culture experiment, it is at once clear that serious mistakes may be made. A low content of a particular element in the leaf does not necessarily mean that this element is deficient. Thus the potassium content of leaves may be low, when nitrogen is deficient. Low calcium and magnesium figures are often associated with phosphorus deficiency. Although it is generally true that the first stage of a deficiency is accompanied by a decrease in the leaf content of that particular element, the reverse is not true, *i.e.* a low content of a particular element in the leaf is not always an indication that this element is deficient. Similarly, a medium to normal concentration of an element is no guarantee that this element is not seriously deficient.

It has been shown that a low content may be a secondary effect of another deficiency. Moreover, when an element is deficient, the concentration of that element may first decrease, but increase again in the later stages of the deficiency. This was, for instance, the case for the phosphorus content in this experiment. Similar cases for copper and phosphate have been found and explained by F. Steenbjerg[10]. It is therefore maintained that interpretations based on 'critical levels' may not serve as a reliable indication of a deficiency. Lundegårdh, using index values to express the quantities of elements in oats and rye, adopts more or less this principle, by taking into consideration also the index values of the elements other than the deficient ones, when estimating the probable response to a particular fertilizer.

Both the foliar diagnosis school of Montpellier[11] and G. W. Chapman and N. H. Gray[12] consider the ratios between the elements of primary importance for the diagnosis of deficiencies. Chapman and Gray used the potassium/phosphorus ratios as an indication of the nutritional status of oil palms. The ratios between the potassium, calcium and magnesium contents for all the treatments are given in *Table 5*. It may be seen from this that there is no advantage in expressing the data as ratios or as a percentage of the sum of the cations. *Table 5* shows that first stages of nitrogen deficiency are almost identical with potassium deficiency; whilst the latter stages of nitrogen deficiency would be interpreted as a normal leaf composition. When phosphate is deficient, the ratios between potassium, calcium and magnesium may be similar to those for normal, calcium or magnesium deficient palms, and a high potassium/phosphorus ratio may be caused by phosphate deficiency, but equally well by magnesium or calcium deficiency.

The presentation of the data in a triangular diagram, or as ratios between any two elements does not therefore provide a sound basis for the diagnosis of deficiencies despite the fact that, under local conditions, highly significant correlations may be found between these ratios and the production of palms.

Table 5. Ratios between potassium, calcium and magnesium contents of 'normal' and mineral-deficient oil palms

Treatment	Element in leaf percentage	1954								1955			
		Feb.	Mar.	April	May	June	July	Aug.	Dec.	Jan.	Feb.	Mar.	April
Complete	K	67	68	70	68	75	70	73	77	71	72	73	77
	Ca	22	23	21	23	18	20	16	17	22	18	16	15
	Mg	11	9	9	9	7	10	11	6	7	10	11	8
Minus nitrogen	K	68	61	64	63	57	63	71	70	67	69	72	71
	Ca	22	26	23	22	33	26	21	20	24	21	18	19
	Mg	10	13	13	15	10	11	8	10	9	10	10	10
Minus phosphorus	K	70	65	70	69	78	70	74	74	71	73	73	79
	Ca	22	25	22	21	16	19	17	22	21	17	17	14
	Mg	8	10	8	10	6	11	9	4	8	10	10	7
Minus potassium	K	63	54	54	58	59	47	61	47	42	45	45	43
	Ca	26	32	32	29	27	36	27	32	38	32	32	30
	Mg	11	14	14	13	14	17	12	21	20	23	23	27
Minus calcium	K	71	68	73	76	82	76	80	82	76	76	79	83
	Ca	20	21	18	14	11	12	11	9	13	13	10	6
	Mg	9	11	9	10	7	12	9	9	11	11	11	11
Minus magnesium	K	68	68	71	67	76	66	72	71	69	72	75	76
	Ca	23	25	23	24	20	24	22	23	24	20	19	19
	Mg	9	7	6	9	4	10	6	6	7	8	6	5

* Expressed as a percentage of potassium + calcium + magnesium.

The results of the present investigations confirm the earlier conclusions of the 'Institut de Recherches pour les Huiles et Oléagineux' workers in French Equatorial Africa and Broeshart (Belgian Congo) that there appears to be an optimal or normal leaf composition. Palms with an adequate supply of plant nutrients, whether growing in a light sand, a heavy clay or a culture solution, have this normal leaf composition. It is not dependent on soil type and is identical for young and old palms, provided a standard sampling technique is strictly adhered to. Any deviations from this normal leaf composition indicate unfavourable nutritional conditions. A deficiency of one element is generally associated with a decrease in the leaf content of that element. In an advanced stage of the deficiency, however, the content of the deficient element may increase again to a medium to normal concentration. Any particular deficiency also influences the concentration of other elements in the leaves, not being deficient in the nutrient medium. The latter may increase or decrease, depending on the nature and the degree of the deficiency. The results of the experiments suggest that the diagnosis of nutrient deficiencies is only satisfactory by means of the recognition of the characteristic deviations from the normal leaf composition of the contents of all the elements in the leaf tissue. These deviations are characteristic with regard to the nature and the degree of the deficiency.

SUMMARY

Monthly foliar analysis of oil palms, growing under controlled nutritional conditions in a sand culture experiment during a 16 month period, led to the following conclusions:

(*1*) Diagnosis of deficiencies should not be based on the concentration of one single element in the leaf tissue. In this respect, the use of critical values for diagnostic purposes constitutes a wrong interpretation as it implies that the level of one single element only is considered in the interpretation of the data.

(*2*) The expression of the data as ratios between two or more elements does not provide any more essential information than the critical values for diagnostic purposes and may even lead to a wrong diagnosis.

(*3*) It is concluded that a satisfactory basis for the diagnosis of deficiencies from foliar analysis data is afforded by the recognition of the characteristic deviations from the normal leaf composition of the contents of all the elements in the leaf tissue.

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REFERENCES

[1] Prevot, P. and Ollagnier, M. (1951). Application de Diagnostic Foliaire, à l'Arachide. *Oléagineux* **6,** No. 6, June

[2] — (1953). Les Bases du Diagnostic Foliaire: Application a l'Arachide. *ibid* **8,** No. 2, Feb.

[3] — and Ollagnier, M. (1953). Engrais Minéraux et Oléagineux Tropicaux. *ibid*, **8,** No. 12, Dec.

[4] Scheidecker, D. and Prevot, P. (1954). Nutrition Minérale du Palmier à Huile à Pobé (Dahomey). *ibid* **9,** No. 1, Jan.

[5] Broeshart, H. (1954). The use of Foliar Analysis in Oil Palm Cultivation. *Trop Agriculture, Trin.* **31,** 251

[6] — (1955). The Application of Foliar Analysis in Oil Palm Cultivation. Thesis, Wageningen

[7] Hewitt, E. J. (1952). Sand and Walter Culture Methods used in the Study of Plant Nutrition. *Com. Bur. of Hort. Plant Crops*, East Malling, *Tech. Com. No.* 22

[8] Goodall, D. W. and Gregory, F. G. (1947). Chemical Composition of Plants as an Index of their Nutritional Status. *Imp. Bur. of Hort. Plant Crops Tech. Com.* No. 17

[9] Ulrich, A. (1948). *Plant Analysis. Methods and Interpretation of Results. Diagnostic Techniques for Soil and Crops.* Amer. Potash Institute, Washington

[10] Steenbjerg, F. (1951). Yield Curves and Chemical Plant Analysis. *Plant and Soil* III No. 2

[11] Lagatu, H. and Maume, L. (1943). Determination par la plante cultivee, de la valeur nutritive d'un milieu cultural. *C. R. Acad. Sci., Paris* **216,** 753

[12] Chapman, G. W. and Gray, N. H. (1949). Leaf Analysis and the Nutrition of the Oil Palm. *Ann. Bot., Lond.* **52,** Oct.

[13] Prevot, P. and Ollagnier, M. (1954). Peanut and Oil Palm Foliar Diagnosis Interrelations of Nitrogen, Phosphorus, Potassium, Calcium and Magnesium. *Plant Phys.* **29,** (No. 1) 26

Book Reviews

LAND AND PEOPLE IN NIGERIA

K. M. Buchanan and J. C. Pugh. University of London Press: London, 1955. 252 *pp.* (illus.) 35*s*

Where agricultural books are scarce, agriculturists often have good cause to be grateful to geographical writers. Chapter III provides probably the most useful general account of modern Nigerian agriculture that has been published. The emphasis in this part is on economic rather than agronomic aspects, but in other sections of the book there are treatments of geology, climate, vegetation, and soils which will also be valuable to the agriculturist. The text is interspersed with very numerous maps, which are stated to be the most important part of the volume.

There is little in the authors' treatment that will irritate an agricultural reader. It is, however, exasperating that authors can still refer to crops by vernacular names without botanical equivalents, so that for instance the non-Nigerian reader is left guessing what crop *tamba* may be. There seems here to have been an unusually long time-lag between writing and publishing; many statistics in the book refer to the period 1948–50, and references to literature quoted hardly go beyond 1951.—G.B.M.

FLAYING AND CURING OF HIDES AND SKINS AS A RURAL INDUSTRY

A. Aten, R. F. Innes and E. Knew. Food & Agriculture Organisation: Rome, 1955. 7*s* 6*d*

F.A.O. Agricultural Development Papers are largely intended for those working in areas where the science of agriculture is not highly developed, which implies most tropical countries. The production of hides and skins is a large item in the revenue of a number of these countries but every year great losses are incurred by the incorrect handling of these products. This booklet sets out to instruct how to obtain a clean hide or skin without cuts or bacterial contamination. The recognized systems of curing are clearly described with the aid of good diagrams and photographs, emphasis being placed upon the practical aspects of particular value in rural areas, where small quantities of hides and skins are periodically handled.

Suspension drying is recommended in hot dry areas and salt curing in hot areas where high humidities are encountered. In general, in hot climates hides and skins can be more easily damaged by bad management than elsewhere and the aim should be to remove the moisture from the skin as quickly as possible.

The various aspects of hide and skin damage both before and after death are dealt with in detail. Grading and management subsequent to drying and salting are discussed and another chapter provides a good illustrated description of equipment and its use. The book also includes a glossary and list of the more important references. The authors have accomplished,

in a very readable style, what they set out to do, but the reviewer would like to make another plea for a more substantial cover and binding for these F.A.O. publications since, if any reference work is likely to be of value, it will receive much handling.—J.R.H.

COTTON GROWING PROBLEMS

B. G. Christidis and G. J. Harrison. McGraw-Hill: New York, 1955. 633 *pp.* (illus.) $9.75

The title of this book does it less than justice, it is more than a discussion of cotton growing problems, the contents constitute a comprehensive treatise on all those aspects of cotton growing with which the producer of cotton is concerned. From the first chapter which deals with varietal characteristics and problems of breeding, the subsequent sections deal logically and comprehensively with the cultural side—rotations, fertilizers, planting, harvesting, *etc.* There is also a useful chapter on insect pests and diseases.

While the emphasis is naturally on cotton production in the United States, full reference is made to problems associated with production in other cotton growing countries and the book summarizes, in the appropriate chapters, the results of experimental and investigational work which has been undertaken throughout the cotton growing world. In this connection the bibliographies which are given at the end of the chapters are most useful.

The book is well and attractively presented, it is up to date and it forms a very welcome addition to the literature dealing with tropical crops.—A.B.K.

AGRICULTURAL MECHANIZATION IN THE TROPICS

Report on the Regional Technical Meeting and Training Centre on Farm Mechanization and Workshop Problems. F.A.O. Report No. 467. 15 *pp*; *Some Aspects of the Development of Farm Mechanization in North America, Europe, and Asia.* F.A.O. Informal Working Paper, No. 1. 21 *pp.*; *Mechanization Project Planning and Management.* F.A.O. Informal Working Paper, No. 2. 52 *pp.*; *The Selection and Operation of Land Development and Agricultural Machinery.* F.A.O. Informal Working Paper No. 3. 34 *pp.; Machinery Training and Advisory Services.* F.A.O. Informal Working Paper No. 4. 34 *pp.*; *Machinery Maintenance.* F.A.O. Informal Working Paper No. 5. 47 *pp.*; *Small Implements and Machines.* F.A.O. Informal Working Paper No. 6. 9 *pp.*

These informal working papers should not be regarded as official publications of the F.A.O., but they constitute a most useful collation of the technical proceedings of the Regional Technical Meeting and Training Centre on Farm Mechanization and Workshop Problems, Ceylon, September–October, 1955; and they are, in effect, appendices to F.A.O. Report No. 467 which deals with the meeting from an administrative point of view.

The informal working papers contain a mixture of conventional agricultural mechanics and recent experience of mechanization in underdeveloped areas. Informal Working Paper numbers 2, 3 and 4 will be of special interest to agricultural planners, while number 5 contains much for the mechanic supervisor or workshop manager. Although number 6 is of very limited scope, it effectively draws attention to the opportunities for improving small implements and hand tools.—J.E.M.

AGRICULTURE IN THE WORLD ECONOMY

Food and Agriculture Organisation. Her Majesty's Stationery Office: London, 1956. 76 *pp.* (illus.) 5*s*

The flood of statistics and studies that emanate from Rome tend paradoxically enough to obscure the great value of F.A.O. as an observer of world agriculture. The specialist, although well served in his own subject, rarely has cause to consult other specialities while the layman is in danger of being confounded by the volume of information available; thus neither can fully appreciate the scope of the work of F.A.O. There is need from time to time to produce non-specialized summaries of the facts and figures collected in Rome and this booklet is designed to fulfil the need.

In a surprisingly small and well planned space the salient facts and figures required to relate agriculture to other industrial activity of the world are presented. The writing is compact and clear, the diagrammatic illustrations numerous and attractive. Considering the vast store of statistics from which this information has been produced the booklet represents a fine feat of digestion. It is to be expected that within such a confined space it is not possible to give exact definitions of most of these statistics nor to explain fully certain facts (such as agriculture receiving an ' unfairly ' small share of the world's income). These necessary shortcomings will not weaken the main purpose of the publication which is to make the politician and the industrialist see the agricultural industry in clearer perspective in the economy of the world and of his own country.—A.L.J.

ERRATUM

It is regretted that the following errors were made in the translation of the article by J. G. Ossewaarde in the April issue: p. 91, line 2 ' soaked ' should read ' decorticated ' and p. 92, line 9 ' widening ' should read ' removing '.

Recent Publications of The Imperial College of Tropical Agriculture

Studies in West Indian Soils, XII: The Agricultural and Forest Soils of St. Lucia, by F. HARDY and G. RODRIGUES. 5*s*

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Reprints are available, at varying prices, of articles in the Cacao Research Reports, including the Colour-Illustrated Guide to the Diagnosis of Mineral Deficiencies in Cacao (1945–1951 Report)—Price 5*s* plus postage.

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Flora of Trinidad and Tobago: This Flora, which has been issued irregularly in parts since 1928, is a compilation of the work of many authors. The early parts, mainly by R. O. WILLIAMS, were edited by the Department of Agriculture of Trinidad and Tobago, but since the end of the second world war editing has been taken over by the Botany Department of the Imperial College. The Flora may be obtained either from the Department of Agriculture or from the Imperial College. The following parts have been published :

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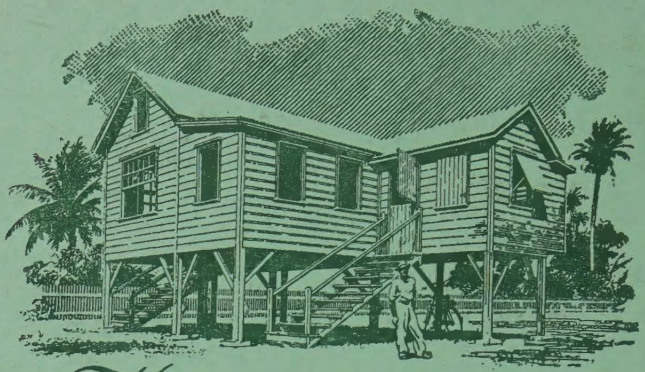

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